The Transaction between Neural Systems
and the Intensive Care Unit Environment:
Development of Neuro-Interior Response Theory

by

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Abstract

This study explores the transaction between neural response and ICU environments. The aim of this study is to explore the relationship between neural response and ICU design, how neural response affects patient healing in the ICU and how neural response and ICU design affect patient health. Transactional theory creates a theoretical grounding for neurological processes needed for the brain to interact with its environment. Neuroscience research will help to explain how patients respond to ICU design neurologically, allowing insight into how interior design affects patient psychological health short and long-term. The method uses content analysis to develop patterns of results throughout neuroscience and interior design research. Content analysis reveals the connection between neuroscience and neuroaesthetics, neuroscience and interior design, and neuroaesthetics and interior design. This study also uses Pandit's (1996) theory building exercise to develop the neuro-interior response theory. The neuro-interior response theory establishes the connection between neural response and interior environments. Neuro-interior response theory recognizes that the brain reacts to different aesthetic environments and creates a response according to endless associations.

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CHAPTER 1:

INTRODUCTION

The healthcare industry is currently undergoing a drastic transformation in design and technological solutions. The ongoing transformation of technology in modern society and scientific findings has led to continual medical advances that solve underlying health risks within healthcare spaces. In recent years, research findings have allowed healthcare focused interior designers to develop safe and hospitable environments that encourage health and wellness for users, patients, and staff. (Bazuin & Cardon, 2011; Cesario, 2009; Charles, Glover, Bauchmüller, & Wood, 2017; Fontaine, Briggs, & Pope-Smith, 2001). Humanistic healthcare design come as a response to thriving medical industries and continuous expansions in industry standards, growing aging populations, and new medical technologies (Phares, 2011).

In the past, healthcare spaces were dull, sterile environments that were designed around staff and cost efficiency (Meyer, 1971; Phares, 2011). Intensive care units (ICU) – an area of a hospital or healthcare facility dedicated to treated critically ill patients - were traditionally designed simply with beige, blank walls and crowded medical technologies around the room (Phares, 2011; Bazuin & Cardon, 2011). The ICU floor plan was so standardized that Meyer (1971) patented the plan to encourage hospitals to maximize on efficiency. While Meyer's (1971) floor plans provided a guideline for industry standards, they lacked engagement for patients and space for visitors, windows, and storage. Spaces such as these led to depressive symptoms and ICU syndrome- a type of depression resulting from a traumatic event and long ICU stay (Granberg, Engberg, & Lundberg, 1996, & 1998). The ICU can overlook the importance of psychological and physical health because of efficiency protocols and delayed patient symptoms (Pati, Hou, & Ghamari, 2016). Numerous studies have found that psychological health can determine short- and long-term medical outcomes among ICU patients (Devlin & Arnell, 2003; Ulrich, 2001; Livingston, Tripp, Biggs, & Lavery, 2009; Pati, Hou, & Ghamari, 2016).

Healthcare design eventually gravitated towards more humanistic environments around the beginning of the 21st century after decades of evidence-based studies - using credible research to base decisions for the built environment - that disclosed the outcomes of dull environments have on user psychosis (The Center for Health Design, 2020; Carmel-Gilfilen, & Portillo, 2016; Bazuin & Cardon, 2011). The movement towards a more humanistic environment also applies to ICUs. ICUs are, typically, technology-forward spaces that focus on providing enough space for medical supplies and staff to properly do their jobs (The Center for Health Design, 2020; Carmel-Gilfilen, & Portillo, 2016; Bazuin & Cardon, 2011). While technology and efficiency are important, old ICU models neglect the psychological needs of patients. ICUs are beginning to adopt patient-centered designs and technological innovations to encourage wellness and patient satisfaction for better patient health outcomes (Bazuin & Cardon, 2011; Fontaine et al., 2001; Rashid, 2011). Ulrich (2001) stated that more supportive design can reduce stress, pain, sleep quality, infection rates, satisfaction, and cost savings on medical outcomes for hospitals. Bazuin and Cardon's (2011) listed amenities that make a humanistic ICU space including family connections, technology that adds human touch (i.e. Skype, TV), calming elements (i.e. access to nature, private rooms), patient-controlled comfort (i.e. lighting, music), and less harsh architecture. Incorporating even a few of these elements will help increase patient engagement and satisfaction.

Neuroscience- science of the brain and nervous system- research can provide insight on how the brain processes its external environment and provide scientific justification for the importance of interior design in all types of spaces (Bower, Tucker, & Enticott, 2019; Bromberger, Sternschein, Widick, Smith, & Chatterjee, 2011; Chatterjee, 2003; Coburn, et al., 2020; Eberhard, 2009; Mirkia, et al., 2012; Nanda, Pati, & McCurry, 2009; Pearce, et al., 2016; Salingaros & Masden, 2008). Neuroscience extends past medical science with branches of research that focus on the experience of the brain rather than the complications of the brain (Salingaros & Masden, 2008; Mirkia, et al., 2012; Nanda, Pati, & McCurry, 2009). The brain is one of the most complicated organs in the body and neuroscience research is continually delving into new research topics to understand its processes. Visual and architectural neuroscience that focuses on the aesthetics of the brain and are used in this study as a tool to create a direct correlation between interior design with the ICU environment (Salingaros & Masden, 2008; Mirkia, et al., 2012; Nanda, Pati, & McCurry, 2009).

Few research studies have explored the connection between neural response and interior design in patient satisfaction. Connecting neural - within the brain and nervous systems - response and interior design to patient health will set a precedent for how future ICU environments are designed (Bromberger, et al., 2011; Chatterjee, 2003; Coburn, et al., 2020; Eberhard, 2009; Mirkia, et al., 2012; Nanda, Pati, & McCurry, 2009). Therefore, the ICU environment becomes a pivotal part of the emotional response of ICU patients.

Purpose

The purpose of this study is to explore the transaction between neural response and ICU environments. ICU design has historically provided little engagement for the user and are designed around maximum efficiency for staff, medical technologies for medical practice, and cost effectiveness for hospital cost. Evidence-based research studies in interior design have found that engaging, calming spaces are ideal for patients recovering from trauma (Phares, 2011). This study will examine neuroscience and interior design research to determine a pattern between psychological health, medical outcomes, and ICU design. Neuroscience research can establish a pattern of neural responses to the ICU environment to create a correlation between the brain and the ICU environment.

This study will follow these objectives:

1. Explore the relationship between neural response and ICU design.
2. Describe how neural response affects patient healing while staying in the ICU.
3. Explore how neural response and ICU design affect patient psychological health.

Background

Healthcare design strives to create a safe and healing space for patients together with a functional, efficient space for healthcare professionals (Bazuin, 2011; Cesario, 2009; Charles, Glover, Bauchmüller, & Wood, 2017; Fontaine, Briggs, & Pope-Smith, 2001). In the past two decades, innovative healthcare spaces have been designed to maximize user needs while creating impressive architecture (Ulrich, 2011). ICU interior design is a section of the hospital that has not equally developed the same innovative and comfortable design like other hospital spaces. Lack of design innovation in the ICU is mostly due to intensive medical technologies and the need for function over aesthetic, but ICU design often overlooks the psychological stress of the patient within a foreign environment after major trauma (Granberg, Engberg, & Lundberg, 1996, & 1998; Pati, Hou, & Ghamari, 2016).

Neuroscience research has recently delved into studies about how the brain processes aesthetic and architectural beauty (Bower, Tucker, & Enticott, 2019; Bromberger, et al., 2011; Chatterjee, 2003; Coburn, et al., 2020; Eberhard, 2009; Mirkia, et al., 2012; Pearce, et al., 2016; Salingaros, & Masden, 2008). Science has determined that the brain processes everything the body does, including its external environment (Bower, Tucker, & Enticott, 2019; Bromberger, et al., 2011; Chatterjee, 2003; Coburn, et al., 2020; Eberhard, 2009; Mirkia, et al., 2012; Pearce, et al., 2016; Salingaros, & Masden, 2008). Neuroaesthetic studies – the study of how the brain processes beauty – are relatively new to neurology research, having been founded in the last 20 years (Chatterjee, 2010). Some neuroaesthetic studies have used art to determine what the brain considers beautiful and why (Chatterjee, 2010). Researchers have found that the human brain responds to organic forms more positively than harsh or sharp forms (Chatterjee, 2003 & 2011; Brinkmann, Boddy, Immelmann, Specker, Pelowski, Leder, Rosenburg, 2018; Bromberger, Sternschein, Widick, Smith, 2011). This science can be translated to interior design through the same concepts and guidelines established for beauty. Modern healthcare spaces often feature needs found from evidence-based design studies such as: access to nature, organic forms, and soothing colors choices that are aesthetically appealing (Ulrich, 2011). Applying neurology to interior design gives significance to the design environment and applying ICU interior design to neurology creates symbolical associations that can be useful to patient psychological health.

Research Questions

The objective of this content analysis is to establish a foundation for exploration into the emotional response of an ICU patient's brain when responding to the ICU environment. Research has suggested that the brain has an automatic neural response through the eyes to its environment (Bromberger, et al., 2011; Coburn, et al., 2020; Eberhard, 2009; Mirkia, et al., 2012; Pearce, et al., 2016; Salingaros, & Masden, 2008).). A focus in healthcare design studies has been to improve patient well-being, patient satisfaction and maximize efficiency through evidence-based design studies (Ulrich, 2011; Phares, 2011). Neurological studies of aesthetics have largely focused on art and exterior architecture (Bromberger, et al., 2011; Chatterjee, 2003,

& 2010; Coburn, et al., 2020; Eberhard, 2009; Mirkia, et al., 2012; Pearce, et al., 2016; Salingaros, & Masden, 2008) which leaves many questions about the interior environment. Thus, the goal of this study is to explore the phenomena of neural response of the ICU environment and neuroaesthetics by conducting a content analysis of neurology and interior design research to serve as a foundation for a longitudinal study on the transaction process.

The following research questions are explored in this study:

RQ1: Is there a phenomenon between neuroaesthetic response and the ICU environment?

RQ2: What research exists regarding neuroaesthetics and the ICU environment?

RQ3: Can assumptions be made from research regarding the ICU environment and neuroaesthetics?

Significance

This study constructs an argument for the use of neuroscience in interior design. By examining current research, this study will establish a pattern for better medical outcomes, psychological health, and satisfaction in ICU patients. Using the transactional model of stress and coping will help to create theoretical grounding for how the brain relates to its environment. As a framework for this study, neuroscience research will help to explain how patients respond to ICU design neurologically, allowing insight into how interior design affects patient's short- and long-term psychological health. Conducting this study will set a precedent for the future of healthcare environments and how designers construct humanistic medical interiors.

Definition of Terms

These terms have been defined for the needs of this study and may vary in definition outside of this thesis. Terms are defined in Table 1.

Table 1.

Definitions.

Term	*Definition*
Neuroaesthetic response	The study of brain reaction to the physical environment and how the brain perceives beauty (Brown & Dissanayake, 2009; Nanda et al., 2009; Chatterjee, 2010).
Intensive care unit (ICU) design	Design for healthcare interiors used for patients with life-threatening conditions or end-of-life care (Gullo et al., 2009; Ferri, Zygun, Harrison, & Stelfox, 2015; Fontaine et al., 2001).
Patient	Someone under the care of an intensive care unit (Devlin & Arneill 2003; Quan, Joseph, & Nanda, 2017).
Patient satisfaction in design	A measurement of how well a patient enjoys a design or space (Fridh, Forsberg, Bergbom, 2008; Gullo et al., 2009; Stichler, 2011).
High stress environment	A space that evokes a heightened feeling of mental strain (Cesario, 2009).
Healing environment	A space that promotes physical, psychological and physiological well-being (Bazuin & Cardon, 2011; Salonen, Lahtinen, Lappanlainen, Navela, Knibbs, Morawska, & Reijula,

	2013). Knibbs, Morawska, & Reijula, 2013; Fontaine, et al., 2001; Carmel-Gilfilen & Portillo, 2016; Stichler, 2011).
Humanistic environment	Critical care environment with regards to human comforts physically and emotionally (Fontaine, et al., 2001).
Evidence-based design	Applying knowledge from empirical evidence, research, and practice to make design decisions that encourage better healthcare outcomes (Ferri, et al., 2015; Ferris, 2013).
Appraisal	The associations of one's personal well-being; primary appraisal is concerned with motivational relevance, secondary appraisal deals with cognitive process on evaluative judgements (Lazarus & Folkman, 1987).
Coping	Behavioral response that measured aversive environmental conditions; ego defense (Lazarus & Folkman, 1987).
Psychological health	Health of the mind; stable brain function of patients (Granberg, Engberg, & Lundberg, 1996; Braver, Cohen, & Barch, n.d.).

CHAPTER II:

REVIEW OF LITERATURE

Theoretical Framework

Transactional theory was originally founded by Louise Rosenblatt who defined *transactional theory* as a formation of meaning between a reader and text (Rosenblatt, 1988). The theory was originally formed to explain the transaction that happens when expressing or reading language (Rosenblatt, 1988). This transaction varies based on social, cultural, natural, and personal elements that effectives our thought process (Rosenblatt, 1988). Rosenblatt's (1988) theory described the term *transaction* to "designate relationships in which each element conditions and is conditioned by the other in a mutually-constituted situation" (p. 2). Rosenblatt (1988) suggested that the reader is reading aesthetically and that aesthetic pulls from personal experiences to infuse aesthetic experience (Maherni, 1998).

The transactional model of stress and coping establishes a mutual relationship between the individual and the external environment to analyze coping with external stressors (Goh, Sawang, & Oei, 2010; Lazarus, & Folkman, 1987). Lazarus and Folkman (1987) originally suggested this model as an extension of Rosenblatt's transactional theory. Lazarus and Folkman (1987) suggest that transactions work through a self-appraisal system that determines how to react to the body's exterior. Originally shown in Lazarus and Folkman's (1987) article, Figure 1 explains the transaction of emotion processing and how external factors can lead to long-term effects.

Figure 1.

Illustrative system variables for the emotion process (Lazarus & Folkman, 1987).

Causal antecedents →	Mediating processes →	Immediate effects →	Long-term effects
Person variables:	Encounter 1...2...3...n		
Values, commitments, and goals	Within an encounter time 1...2...3...n		
General beliefs, e.g.			
Self-esteem			
Mastery			Psychological well-being
Sense of control	Primary appraisal (stakes)	Affect	
Interpersonal trust			
Existential beliefs	Secondary appraisal (coping options)	Physiological changes	Somatic health/ illness
Environmental variables:	Coping (including use of social support):	Quality of encounter outcome	Social functioning
Demands			
Resources, e.g. social support network	Problem-focused forms		
Constraints	Emotion-focused forms		
Temporal aspects			

Note. Although not shown here, the model is recursive. Also, note parallelism between short- and long-term effects.

Goh, Sawang, and Oei (2010) revised the original model created by Lazarus and Folkman (1984) and found that “stressful psycho-physiological arousal” (p. 14) from the environment initiates an automatic coping response leading to a higher “level of psycho-physiological stress experiences” (p. 14). These findings suggest that stressful situations lead to a higher psychological response, such as in the ICU. Salingaros and Masden (2008) found that design has surpassed the brain’s abilities to process exaggerated shapes. While ICU environments do not, typically, have aesthetically innovative designs, it does, however, have exaggerated shapes of technologies necessary for healthcare (Rashid, 2011).

The transactional model of stress and coping is ideal to use in this study to provide outline for the transaction process between the brain and the ICU. The model also provides a grounding to previous research, setting precedent for the study.

Transactional Model of Stress and Coping

The transactional model of stress and coping creates a conjoint connection between the individual and their external environment to explore how they cope with external stressors (Goh, Sawang, & Oei, 2010; Lazarus & Folkman, 1987). In this section, the model is explained in more detail and how it is becomes relevant to interior design research. Recapping, Lazarus & Folkman (1987) suggested that transactions work through a self-appraisal system that determines how to react to the body's exterior. The model describes the experience of stress as a "consequence of the interaction between the stressor and the individual's perception of control over the stressor" (p. 4, Goh, Sawang, & Oei, 2010) meaning stress appraisal varies based on the individual but can be evaluated based on Lazarus and Folkman's stress appraisal system.

Stress response emerges from "negative person-environment relationships" (p. 142), self-appraisal of the environment, and emotional response (Lazarus, & Folkman, 1987). The appraisal model created by Lazarus and Folkman (1987) explains the transaction the relationship creates using understandable language, ideal for patient-staff use in the ICU. Appraisal can be defined as a way to evaluate one's well-being and comes in two forms in this model: primary and secondary.

Primary appraisal, in this model, assesses why stress is happening and the motivational reasoning behind it (Lazarus & Folkman, 1987). Primary appraisal allows the individual to identify stress-related issues. This form of appraisal divides stress into three categories: harm, threat, and challenge (Lazarus & Folkman, 1987). Lazarus and Folkman (1987) describe these three categories simply by stating "harm already experienced; threat, which is harm that is anticipated; and challenge, which is the potential for mastery or gain" (p. 145). When evaluating their study, it became simple to think of the three categories of primary appraisal as stress from the past (harm), present (challenge), and future (threat). Lazarus and Folkman (1987) later acknowledge measurements for primary appraisal through cognition and emotion. Cognition acknowledges the stakes a person has in a stressful situation, and emotion can be recorded during the stressful situation (Lazarus & Folkman, 1987). Through Lazarus and Folkman's (1987) method and the method evaluating in this study, stress can be identified and singled out into a particular event.

Secondary appraisal was also identified in Lazarus and Folkman's (1987) study. This form of appraisal is used as a supplement to primary appraisal and may be used to identify evaluative judgements that may be needed to help an individual improve on the stress created from a particular event (Lazarus & Folkman, 1987). The individual may use a secondary appraisal method by asking evaluative questions to themselves such as "was the encounter one that could be changed; had to be accepted; required more information before acting; required holding oneself back" (p. 152, Lazarus & Folkman). These questions will lead to the types of coping mechanisms needed to overcome stress.

Coping comes after one has appraised their stress to develop an answer as to where the stress originates. Lazarus and Folkman (1987) described two types of coping functions: the person-environment relationship and managing emotional distress. This study will focus on the person-environment relationship coping methods.

Lazarus and Folkman (1987) created a Likert scale that identified eight forms of coping mechanisms: confrontive coping (facing head-on), distancing (getting away from the problem), self-control (kept quiet), seeking social support (help from peers), accepting responsibility (criticizing oneself), escape-avoidance (avoided the problem), planful problem-solving (finding a solution), and positive reappraisal (creating a solution and increasing efforts to find a solution).

This Likert scale can be useful in this study and future studies of ICU patients to evaluate how they dealt with the stress of their environment. Processing the coping mechanisms is the next evaluation necessary. The longevity of coping varies based on the type of stress, the type of coping mechanism, and the individual (Lazarus & Folkman, 1987). In order to determine, how individuals in the ICU process their environments, a future study of patients would be necessary.

Goh, Sawang, Oei (2010) performed an analysis of Lazarus & Folkman's (1987) study for their interview study of stressful events and summarized that the central purpose of the transactional model is that "primary appraisal, secondary appraisal, and coping strategies mediate the relationship between stressor and the individual's stress outcomes" (p. 3). Although the personal accounts of ICU patients are not known, the transactional process of stress and the environment will be a useful evaluation tool while conducting this study to help define the relationship between the patient and their environment.

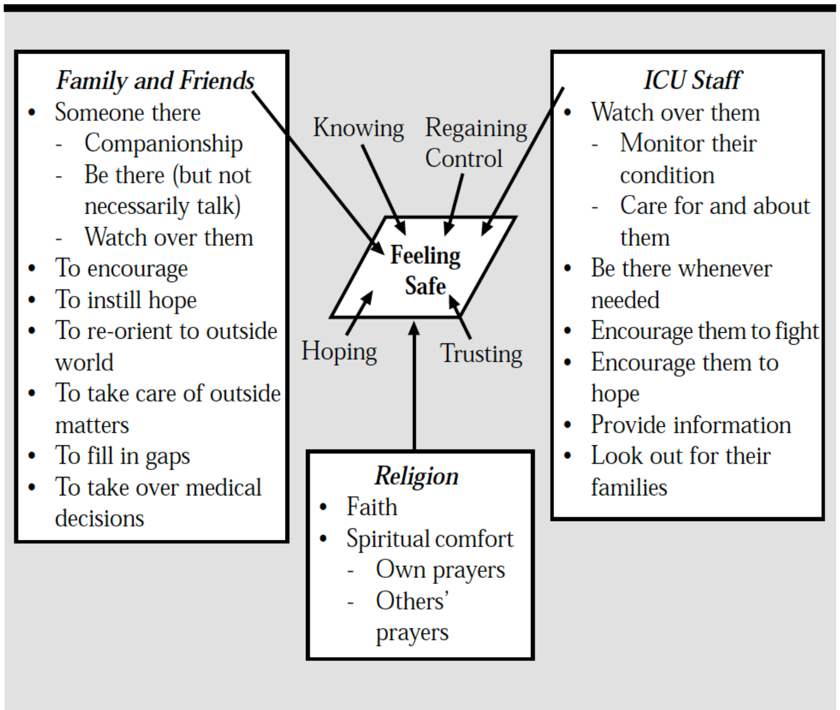
ICU Patients

ICU patients are a specialized type of user within a space. ICU patients have come to be in the ICU as a result of some type of physical trauma that may cause patients to experience their environment differently. Many different factors such as medication, consciousness, and comfort level influences how the patient experiences a space (Hupcey, 2000; Devlin & Arneill, 2003). Patient health is top priority within the ICU, so it is imperative to evaluate patient emotions. Interior design and medical studies have evaluated the purpose of the interior ICU environment so the patient feels comfortable while staff can focus on efficiency (Bazuin & Cardon, 2011; Fontaine, Briggs, & Pope-Smith, 2001). Over the last several decades, healthcare environments have evolved to create comfortable, residential-like spaces for patients to reduce stress and heal (Bazuin & Cardon, 2011; Fontaine, Briggs, & Pope-Smith, 2001). Researchers continue to develop studies that demonstrate the importance of the environment to patient health (Devlin, 2003; Bazuin & Cardon, 2011; Fontaine, Briggs, & Pope-Smith, 2001; Rashid, 2010; Salonen, et al., 2013; Simons, 2018).

Hupcey (2000) conducted a study on former ICU patients to evaluate what made them feel safe during their stay. Hupcey's (2000) study found that patient needs include: feeling safe, knowing, regaining control, hope, trusting, family and friends, ICU staff, and, commonly, religion (Hupcey's (2000) findings are modeled in Figure 2). The three main needs of patients- feeling safe, knowing, and regaining control- are most relevant to this study (Hupcey, 2000). The concept of feeling safe and knowing with patients mostly comes from hospital staff where patients expect the best and want to know exactly what is happening with their bodies (Hupcey, 2000). The patients in Hupcey's (2000) study remember being frightened by the loss of control in their lives. Regaining control may include simple tasks (i.e. changing a TV channel, looking out the window) that patients feel like they have some control over their bodies (Hupcey, 2000).

Figure 2.

Model of the psychosocial needs of patients (Hupcey, 2000).



ICU syndrome

The ICU syndrome is a term worth noting within this study. The ICU syndrome was originally defined by McKegney (1966) and can be defined as "an acute brain syndrome that involves impaired intellectual functioning occurring in patients who are being treated within a critical care unit" (p. 173, Granberg, Engberg, & Lundberg, 1996). ICU syndrome develops from a patient being in a high stress environment for an extended period of time (Granberg, Engberg, & Lundberg, 1996). Development of the disease is organic but factors such as personality, age, emotional conditions, and environmental factors all play a role into the development of the acute brain disease (Granberg, Engberg, & Lundberg, 1996). Symptoms of the disease include delirium, anxiety, nightmares, agony, and panic (Granberg, Engberg, & Lundberg, 1996).

In his original study, McKegney (1966) stated that environmental factors like windowless, impersonal, and unfamiliar ICU spaces may lead to the development of the disease. The mixture of physical trauma and unfamiliarity with one's environment may cause the onset of depressive or panic symptoms that may develop further into an acute brain disease (McKegney, 1966; Granberg, Engberg, Lundberg, 1996). The unfamiliarity with one's environment similarly relates to Hupcey's (2000) study mentioned earlier, where it was found that knowing and regaining control where among the most important way to make a patient feel safe within their space.

ICU Design

A brief history of the ICU is useful to note the continual progress of medical spaces. ICU interior design has evolved into high-paced, technological spaces that promote healing through evidence-based design practices. The famous Florence Nightingale mentioned the importance of a healing environment within healthcare spaces (Nightingale,1860). Nightingale was the first researcher to mention the importance of lighting, noise and sensory stimulation for patient health (Nightingale, 1860; Fontaine, Briggs, & Pope-Smith; 2001). The first official ICUs originated in the 1950s were open rooms with multiple beds with no separation between patients and had little stimulation for patients (Fontaine, Briggs, Pope-Smith, 2001). Stimulating ICU designs that featured more patient privacy began to develop in the 1980s (Fontaine, Briggs, & Pope-Smith, 2001). ICU environments have a promising future with more evidence-based design solutions arising to fix common problems with patient dissatisfaction, discomfort, and staff efficiency (Fontaine, Briggs, & Pope-Smith, 2001). Further, a brief history of the ICU developed by Fontaine, Briggs, and Pope-Smith (2001) can be found in Figure 3.

Figure 3.

History of ICU Designs (Fontaine, Briggs, & Pope-Smith, 2001).

	1st generation 1950s	2nd generation 1970s	3rd generation 1980s—present	4th generation—future
Characteristics	Open unit/ward. No partitions except curtains or screens. Nurses' station/desk in center or at the foot of beds. Unit lighting control often on one switch.	Individual rooms or walled cubicles. Rooms often on either side of a hall containing an open nursing station or surrounding an open nursing station on 3–4 sides (square configuration). Central monitoring. Some units without external patient room windows (increased incidence of delirium). Patient room lighting with separate switch(es) from nursing station. Calendars and clock in patient rooms.	Individual rooms. Folding or sliding glass doors. Rooms often arranged on a semicircle or circle with the nursing station in the center. Some units configured with decentralized nursing stations. Patient room windows with external views/lighting. Increased control of patient room lighting levels.	Individual rooms. Folding or sliding glass doors with privacy curtains/blinds. Circular/pod shaped floor plan. Increased noise reduction designing. Patient windows with a view of outdoors (natural or contrived). Patient-controlled lighting—artificial and natural. Planned areas for family within patient rooms. Increased use of color and texture in wall, floor, and ceiling coverings.
Advantages	Increased nurses' proximity to patients	Increased patient privacy. Better control of lighting, noise, and infection.	Increased nursing access during high-intensity activities.	Nursing access and availability of high-tech care in a more home-like environment.
Disadvantages	Lack of privacy. Inability to control noise or light. Infection control issues.	Less direct patient access/observation. Less than optimal control of noise and lighting.	Glass doors reduce patient privacy.	

Typical Requirements

All ICUs require particular design elements. Every ICU design will differ in some sort of way to fit the footprint of the building's architecture and the needs of the hospital, but every ICU features typicals required in every ICU space. These *typicals*, an interior design field term, are necessary in interior and ICU environments to ensure comfort and efficiency within the space. Typicals are also necessary to mention to consider all aspects of interior design with ICU environments. Many typical requirements are infrastructure related and may not be visible outside of the walls such as: plumbing, electrical, heating and air conditioning, acoustic absorbent materials, and wireless connections (Rashid, 2010). Three of the most important typicals- egress, medical technology, and furniture- should be discussed in further detail.

Egress. Egress is a common design term used to mention clear, accessible pathways within a space (Jiang & Verderber, 2017). Egress is very important to public space for many reasons. In the ICU, egress pathways such as corridors, circulation areas, and open floor space allow for passage for multiple users at a time, wheelchairs, gurneys, and any mobile medical equipment to be easily transported throughout the entire hospital (Jiang & Verderber, 2017; Halpern, 2014; Fontaine, Briggs, & Pope-Smith, 2001; Bazuin & Cardon, 2011). An ICU without proper egress risks efficiency penalties and, possibly, death during emergencies (Jiang & Verderber, 2017; Halpern, 2014).

Medical Technology. There are dozens of essential medical technologies needed in each ICU patient room and wing. Since this study focuses on the patient room, one can note the essential bedside patient room technologies. Typical bedside technology includes "ICU beds, physiologic monitor, mechanical ventilator, infusion and feeding pumps, pneumatic compression devices, patient lift, computers […] laboratory specimen label printer, nurse-call station, webcam, entertainment system, storage areas, and waste disposal bins" (p. 647, Halpern, 2014). Medical technologies evolve constantly over the years, so it is likely that some technologies are missed and some can be added into bedside typicals in the future. Many more technologies are stored within ICU wings for convenience of proximity, ample storage in ICU wings and patient rooms are necessary to eliminate clutter and maintain organization (Halpern, 2014; Rashid, 2010).

Furniture. Furniture typicals in the ICU patient room are something that may vary based on the size of the room. Some furniture, like the ICU bed, are also considered medical technologies, because of their electronic abilities (Halpern, 2014). Halpern (2014) conducted a study on the necessary items for a smart ICU. Among their list of necessities were chairs for patients and family, unsecured and secured storage, nurses' stations, television/entertainment areas, and mobile technology carts (Halpern, 2014).

Healing Design Elements

Multiple studies have been conducted on design elements that make the patient more comfortable and stimulated to induce healing (Lazarus & Folkman, 1987). These studies have found numerous ways to increase the healing quality of the ICU space, so it is worth noting the most common elements that are generally standard in the ICU.

Sound. There is a general consensus among design researchers that the ICU should be a calm, quiet environment, void of any loud disturbances that may cause panic or stress to patients, family, and staff (Bazuin & Cardon, 2011; Fontaine, Briggs, & Pope-Smith, 2001; Halpern, 2014). Sound absorbent materials should be used in ceiling tiles, insulation, flooring, and in soft, but durable furnishings (Bazuin & Cardon, 2011; Fontaine, Briggs, & Pope-Smith, 2001; Halpern, 2014; Rashid, 2010). Acoustic ceiling tiles are a traditional standard in public spaces, but alleviate noise successfully (Fontaine, Briggs, & Pope-Smith, 2001). Soft materials absorb sound and lead to a calmer environment (Bazuin & Cardon, 2011; Fontaine, Briggs, & Pope-Smith, 2001; Halpern, 2014). Sound dampening may be achieved through patient and guest chairs and patient bedding (Halpern, 2014). Multi-bed rooms should have fabric curtains to separate patients for privacy when needed (Halpern, 2014). Music and entertainment centers may also be used in patient rooms to allow for distractions and create a calmer environment (Bazuin & Cardon, 2011; Fontaine, Briggs, & Pope-Smith, 2001; Halpern, 2014; Rashid, 2010). Music and entertainment centers should be controllable by users and easily accessible through the patient's bed for ease of use (Halpern, 2014).

Lighting. A balance of natural and artificial lighting is important in the ICU. Natural lighting with access to a view is a necessity in creating a healing environment (Fontaine, Briggs, Pope-Smith, 2001; Bazuin & Cardon, 2011; Halpern, 2014; Rashid, 2010). Natural light provides necessary vitamin D_3 into the skin and helps to create a positive connection to nature in a space (Fontaine, Briggs, & Pope-Smith, 2001). Natural light can be incorporated through the use of windows or skylights.

Artificial light is more complicated to incorporate into the space. The harsh nature of most commercial lighting can slow melatonin production in the patient and increase stress (Fontaine, Briggs, & Pope-Smith, 2001; Bazuin & Cardon, 2011; Halpern, 2014; Rashid, 2010). Light sources should be mostly indirect with less harsh spectrum bulbs, with minimal overhead procedure lights incorporated (Fontaine, Briggs, & Pope-Smith, 2001). Artificial lighting should be controllable by both the staff and the patient (Fontaine, Briggs, & Pope-Smith, 2001; Bazuin & Cardon, 2011; Halpern, 2014; Rashid, 2010). Giving the patient control over the lighting will help with regaining control in their daily lives (Hupcey, 2000; Fontaine, Briggs, & Pope-Smith, 2001).

Color and Art. Color and art can provide a visual break from the stark medical technologies of the ICU environment. Color affects emotions and psychological response of the patient (Rashid, 2010; Fontaine, Briggs, & Pope-Smith, 2001). Calming colors (blues, greens, violets) are preferred while pastel colors provide an upbeat mood to a space (Rashid, 2010). Artwork should be incorporated into the ICU as well. Artwork should avoid any potentially offensive imagery and should appeal to any type of culture or religion (Rashid, 2010). Art comes in many different subject matters so art that encourages calming is encouraged -landscapes, nature, etc. (Rashid, 2010). Incorporating artwork and color into an ICU space can make up for lack of windows or other interest within the space (Rashid, 2010; Fontaine, Briggs, Pope-Smith, 2001).

Environmental Control. Patient environmental control is important in reducing stress and managing anxiety (Rashid, 2010; Fontaine, Briggs, & Pope-Smith, 2001; Bazuin & Cardon, 2011; Halpern, 2014). Environmental control for patients means control over one's environment and can include simple adjustments (Rashid, 2010; Fontaine, Briggs, & Pope-Smith, 2001). Necessary environmental controls in the ICU patient room include thermostats in each room, adjustable beds, light switches and controls, television/entertainment center controls, communication controls, access to religious needs, and window blinds (Rashid, 2010; Fontaine, Briggs, & Pope-Smith, 2001; Bazuin & Cardon, 2011; Halpern, 2014). Optional environmental controls can include music, aromas, stimulation activities, and access to nature (Rashid, 2010; Fontaine, Briggs, & Pope-Smith, 2001; Bazuin & Cardon, 2011; Halpern, 2014).

Visual Neuroscience

Neuroscience, as previously mentioned, is the study of the human brain and neural systems (Barrett, & Satpute, 2013; Bromberger, Sternschein, Widick, Smith, Chatterjee, 2011; Rybak & Smith, 2009; Salingaros & Masden, 2008). The brain controls all motor and psychological functioning within an animal lifeform (Barrett & Satpute, 2013; Bromberger, et al., 2011). Vision is controlled by the occipital lobe in the cerebral cortex (Amorapanth, Widick, & Chatterjee, 2010; Barrett & Satpute, 2013; Bromberger, et al., 2011). Although the other four senses work together with orient humans for environmental adaptation, vision is the bodily sense that allows the brain to process the objects within the adjacent surroundings (Amorapanth, Widick, & Chatterjee, 2010; Barrett & Satpute, 2013; Bromberger, et al., 2011; Rybak & Smith, 2009; Salingaros & Masden, 2008). Over thousands of years of evolution, the brain has developed patterns for preferred aesthetics that has begun to be studied in neuroscience research (Bower, Tucker, & Enticott, 2019; Bromberger, et al., 2011; Chatterjee, 2003; Eberhard, 2009; Mirkia, et al., 2012; Pearce, et al., 2016; Salingaros & Masden, 2008). This science can be translated to interior design through the same concepts and guidelines established for beauty in neuroaesthetic studies (Bower, Tucker, & Enticott, 2019; Bromberger, et al., 2011; Chatterjee, 2003; Coburn, et al., 2020; Eberhard, 2009; Mirkia, Sangari, Nelson, Sarmadi, & Assadi, 2012; Pearce, et al., 2016; Salingaros & Masden, 2008).

Neuroaesthetics

Neuroaesthetics, as previously mentioned, is a branch of neuroscience that analyzes how the brain experiences the visual environment (Chatterjee, 2010; Nanda, Pati, & McCurry, 2009). This field of study combines aesthetic studies, a branch of philosophy relating to beauty, and neuroscience (Nanda, Pati, & McCurry, 2009). Chatterjee (2003) established a framework for visual aesthetics stating "first, visual aesthetics, like vision, has multiple components. Second, an aesthetic experience is [...] derived from responses to different components of a visual object" (p. 55). Chatterjee's (2003) findings were used to evaluate art and beauty, but the same fundamentals can be applied to the aesthetics of the built environment (Nanda, Pati, & McCurry, 2009).

Emotional Response to Art. Emotions can be measured by neural activity in the brain and can describe the body in different states (Nanda, Pati, & McCurry, 2009). An aesthetic response in the brain will then activate an emotional response (Brown & Dissanayake, 2009; Chatterjee, 2003; Chatterjee, 2010). For this study, analyzing how brain function reacts to high stress environments is critical for the success of the design. Kawabata and Zeki (2004) conducted a study of neural correlate function where participants evaluated art on whether they believed it to be beautiful or not. Their study found that the part of the brain associated with love and pleasure, the anterior cingulate and the left parietal cortex, was the part of the brain activated (Kawabata & Zeki, 2004). Kawabata and Zeki's (2004) findings directly correlate aesthetic response with emotional response. Brown and Dissanayake (2009) noted that "aesthetics must be rooted in the theory of human emotion" (p. 50) to gather a richer view of art in neuroaesthetics. Their study, while related primarily to artwork, suggested that emotion in aesthetics is crucial to the success of perception (Brown & Dissanayake, 2009). The emotional component to aesthetics is crucial in interiors, as it directly relates to how a user feels within a space (Nanda, Pati, & McCurry, 2009). Stressors in a healthcare environment can reflect negatively on the surrounding space, so emotional response in neuroaesthetics is crucial in evaluation of the topic (Nanda, Pati, & McCurry, 2009).

Connecting the Brain to the Environment

Neuroaesthetic research fills a gap in neuroscience research that determines how the brain thinks about aesthetic beauty (Barrett & Satpute, 2013; Bromberger, et al., 2011; Rybak & Smith, 2009; Salingaros & Masden, 2008). The anatomy of the brain and their functions are important to mention to establish context to the research. To analyze how a patient may experience the ICU environment, connecting the brain to its surroundings may determine how the brain processes the aesthetics of the space. Both Figures 4 and 5 were shown in Nanda Pati, and McCurry's (2009) study that connected the research gap between healthcare design and neuroaesthetic studies. Figure 4 show the major parts of the human brain and Figure 5 shows how the brain compartmentalizes different functions within itself.

Figure 4.

The major anatomy of the brain. ***Brain facts: A primer on the brain and nervous system (Society of Neuroscience, 2006).***

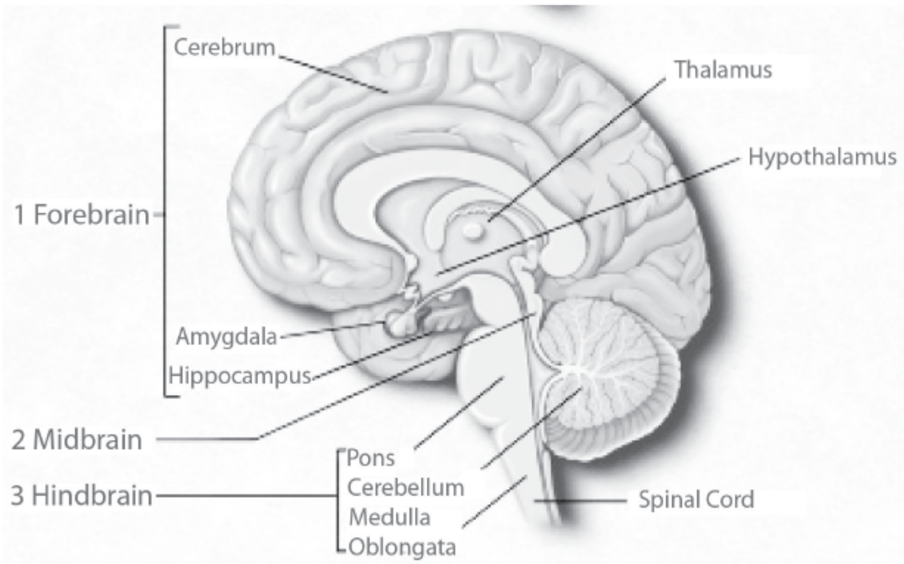
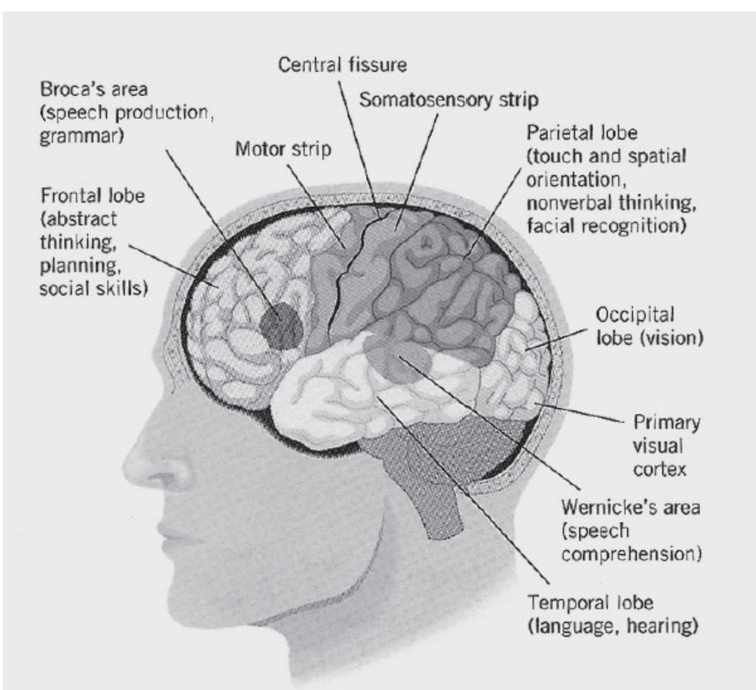


Figure 5.

Cognitive centers of the human brain. ***Psychology: Mind, brain and culture*** **(Westen, 1996).**



Orienting space.

As seen in Figures 4 and 5, space orientation is compartmentalized within the parietal and occipital lobes (Nanda, Pati & McCurry, 2009). This section will focus on how these two lobes allow the body to interact with its surroundings, connecting the brain to its environment, in the hopes that the research will provide insight into how design can manipulate the environment to connect with the brain.

Occipital lobe. The occipital lobe is responsible for vision, houses the primary and association visual cortexes, and is the smallest of the four lobes of the cerebral hemisphere- the outer parts of the brain (Rehman & Al Khalili, 2020; The Human Memory (a), 2020). Rehman and Al Khalili (2020) discuss the processes and anatomy of the occipital lobe in their study. Rehman and Al Khalili (2020) explain that the occipital lobe is the visual processing area of the brain, including "visuospatial processing, distance and depth perception, color determination, object and face recognition, and memory formation" (para. 6).

The primary visual cortex in the occipital lobe receives information from the retinas in the eyes via the thalamus (para. 6, Rehman & Al Khalili, 2020). The primary visual cortex uses two pathways, the dorsal (object location) and ventral stream (object recognition), to transmit information to the secondary visual cortex, temporal and parietal lobes (Rehman & Al Khalili, 2020; The Human Memory (a), 2020). The Human Memory (a, 2020) explains how neurons in the eyes react to the environment using light and auditory stimuli that process signals using photosensitive cells in the retina. The information, finally, passes from the retina to the occipital lobe to the hippocampus, where it becomes a memory (The Human Memory (a), 2020).

Parietal Lobe. The parietal lobe is important to this study as it is responsible for spatial orientation and is used to connect the individual with their environment (The Human Memory (b), 2020; Queensland Brain Institute). This lobe is located behind the frontal lobe and above the occipital lobe, which is separated by the central sulcus (The Human Memory (b), 2020; Queensland Brain Institute). The parietal lobe is also responsible for the somatic senses, which include the sense of touch, pain, proprioception (sense of position and movement), and haptic perception (the sense of grasp) (The Human Memory (b), 2020). The senses the parietal lobe produce allow the human body to sense objects touching the skin and locate objects surrounding the body (The Human Memory (b), 2020; Queensland Brain Institute).

Transaction between Neural Systems and Interior Environments

As mentioned earlier in the chapter, transactional model of stress and coping can be used to define the interaction between ICU patient neural systems and ICU interior environments (Lazarus & Folkman, 1987). Neuroscience research has commonly confirmed that the brain and the body interact with its environment in many different ways (Amorapanth, Widick, & Chatterjee, 2010; Bower, Tucker, & Enticott, 2019; Brinkmann, Boddy, Immelmann, Specker, Pelowski, Leder, Rosenburg, 2018; Bromberger, et al., 2011; Coburn, et al., 2020; Eberhard, 2009; Mirkia, et al., 2012; Nanda, Pati, & McCurry, 2009; Salingaros & Masden, 2008). The transactional model of stress and coping examines how the individual copes with stress cognitively (Lazarus & Folkman, 1984; Goh, Sawang, Oei, 2010). Interior designers also strive to create a connection between the user and the interior space and researchers have proven that certain design elements can affect stress, comfort, emotions, and more (Devlin, 2003; Bazuin & Cardon, 2011; Fontaine, Briggs, & Pope-Smith, 2001; Rashid, 2010; Salonen, et al., 2013; Simons, 2018).

The optic nerve in the brain has been found to prefer certain types of architectural details (Coburn, et al., 2020; Eberhard, 2009; Mirkia, et al., 2012; Nanda, Pati, & McCurry, 2009;

Salingaros & Masden, 2008). Pati, Hou, and Ghamari (2016) did a magnetic resonance imaging (MRI) study on hospital interiors to determine what kind of architectural elements the brain preferred. They found that softer lines ranked significantly higher on their “like” scale while sharp images were high on their “dislike” scale (Pati, Hou, & Ghamari, 2016). They concluded this study by suggesting that contours are very important to the emotional response of patients (Pati, Hou, & Ghamari, 2016). Pati, Hou, and Ghamari’s (2016) study provides evidence that the brain prefers form that feature softer, more natural curvilinear lines. It also helps support the argument that healthcare spaces may provide a negative reaction within the brain (Pati, Hou, & Ghamari, 2016).

Salingaros and Masden (2008) suggested that architecture and design evolved to fast for human evolution, leaving humans with an “imposition of building design against their most basic instincts” (p. 23). This imposition suggests that the human body now has an instinctual nature to respond to architectural elements in the built environment (Salingaros & Masden, 2008). Further studies need to be performed to examine the preferred architectural elements of the human brain, but the transaction between the optic nervous system and the exterior environment can be observed (Lazarus & Folkman, 1987).

The optic nervous system and the occipital lobe instinctually processes its environment (Amorapanth, Widick, & Chatterjee, 2010; Eberhard, 2009; Mirkia, et al., 2012, Salingaros & Masden, 2008). Human bodies have evolved over many millennia to environmental changes on earth (Vink, Bazley, & Jacobs, 2016; Nanda, Pati, & McCurry, 2009). Since the beginning of modern civilization, societies have developed at an increasing pace, but the human body continues to evolve at the same speed (Vink, Bazley, & Jacobs, 2016; Nanda, Pati, & McCurry, 2009). The transactional model of stress and coping acknowledges the stress processed cognitively with external stressors, including unknown environments, such as the ICU (Lazarus & Folkman, 1987). Staff, long-term patients and families are the only users that may come into contact with an ICU environment on a common basis. Between the panic of trauma and the unknown environment, the patient is at a high stress risk (Lazarus & Folkman, 1984; Goh, Sawang, Oei, 2010).

The transactional model of stress and coping can be used to analyze the connection between ICU patients and their exterior stressors (Lazarus & Folkman, 1987; Devlin, 2003; Bazuin & Cardon, 2011; Fontaine, Briggs, & Pope-Smith, 2001; Rashid, 2010; Salonen, et al., 2013; Simons, 2018). Using this model within the study will provide a guideline for the stressors and coping mechanisms common within the human psyche (Lazarus & Folkman, 1987). Stressors are constant for patients during a stay in the ICU. It is important to understand the stress in order to eliminate the unnecessary stressors that may cause panic or lead to worsened physical health (Lazarus & Folkman, 1987). Primary appraisal assesses *why* stress is happening and is used to evaluate stressors into the three categories: harm, threat, and challenge (Lazarus & Folkman, 1987). Through the measurements for primary appraisal, cognition recognizes the risks a person has in a stressful situation, and emotion can be recorded during the stressful event (Lazarus & Folkman, 1987). Secondary appraisal can be used to categorize evaluative judgements that may be needed to help an individual improve on the stress created from a particular incident (Lazarus & Folkman, 1987). The individual may use a secondary appraisal method by asking evaluative questions to themselves that lead to the types of coping mechanisms needed to overcome stress (Lazarus & Folkman, 1987).

CHAPTER III

METHODOLOGY

Introduction

Interior design research has made the link between environment and the user while using evidence-based research to create solutions to design issues, however existing ICU design research on patient satisfaction currently lacks the link between neuroscience and the ICU environment. The method of this study is a content analysis of neuroscience and interior design research towards the development of a grounded theory. Content analysis is a qualitative method of study that involves gathering, processing, and analyzing relevant content. Using content analysis of the existing research will formally establish a link between neuroaesthetics and interior design. The analysis begins with gathering information for data using an open, axial, and selective coding method. The purpose for a grounded theory comes after the information is coded and, hopefully, a connection is formed between neuroaesthetics and interior design.

Scope

This study will be based on interior design and neuroscience research. Interior design is based on aesthetics and focuses on all types of environments. Interior design research in this study will focus on evidence-based design research that cover ICU and healthcare environments. Neuroscience research is very vast and scientific so, to narrow down this topic, neuroscience research will focus on neuroaesthetic studies or neuroscience studies that cover aesthetics and form.

Limitations

To narrow the scope of the study further, this study comes with a few limitations. This study is conducted on a limited number of neurology studies on architecture. This issue arises from the lack of studies conducted on man-made environments, with even less being interior environments. The process of content analysis is time-consuming, meaning the final method data may not be perfect and lack existing research or miss data within research (Maier, 2018). Secondly, the content analysis results can be difficult to generalize across content analyses, as another research may operationalize the data differently (Maier, 2018). The method will generalize findings across all data so the results may be replicated.

Method Explanation

Building Grounded Theory

Developing a grounded theory from research involves a long 5-step process of analysis (Pandit, 1996). Pandit (1996) summarized grounded theory development by identifying a 5-step process of research design, data collection, data analysis, and literature comparison. Table 2 details the process as originally shown in Pandit's (1996) study. This study will follow the step-by-step process provided in Pandit's (1996) summary, but with a few exceptions. The research design phase has already been outlined within the first two chapters of this study, therefore, the methodology will begin from step 3, data collection.

Table 2. ***The Process of Building Grounded Theory*** **(p. 3, Pandit, 1996).**

PHASE		ACTIVITY	RATIONALE
RESEARCH DESIGN PHASE			
Step 1	Review of technical literature	Definition of research question	Focuses efforts
		Definition of a priori constructs	Constrains irrelevant variation and sharpens external validity
Step 2	Selecting cases	Theoretical, not random, sampling	Focuses efforts on theoretically useful cases (e.g., those that test and/or extend theory)
DATA COLLECTION PHASE			
Step 3	Develop rigorous data collection protocol	Create case study database	Increases reliability Increases construct validity
		Employ multiple data collection methods	Strengthens grounding of theory by triangulation of evidence. Enhances internal validity
		Qualitative and quantitative data	Synergistic view of evidence
Step 4	Entering the field	Overlap data collection and analysis	Speeds analysis and reveals helpful adjustments to data collection
		Flexible and opportunistic data collection methods	Allows investigators to take advantage of emergent themes and unique case features
DATA ORDERING PHASE			
Step 5	Data ordering	Arraying events chronologically	Facilitates easier data analysis. Allows examination of processes
DATA ANALYSIS PHASE			
Step 6	Analysing data relating to the first case	Use open coding	Develop concepts, categories and properties
		Use axial coding	Develop connections between a category and its sub-categories
		Use selective coding	Integrate categories to build theoretical framework
			All forms of coding enhance internal validity
Step 7	Theoretical sampling	Literal and theoretical replication across cases (go to step 2 until theoretical saturation)	Confirms, extends, and sharpens theoretical framework
Step 8	Reaching closure	Theoretical saturation when possible	Ends process when marginal improvement becomes small
LITERATURE COMPARISON PHASE			
Step 9	Compare emergent theory with extant literature	Comparisons with conflicting frameworks	Improves construct definitions, and therefore internal validity
		Comparisons with similar frameworks	Also improves external validity by establishing the domain to which the study's findings can be generalised

Data Collection & Ordering

For this study, the researcher was primarily interested in how neural systems process the ICU interior environment by analyzing neuroscience and interior design articles. Data collection is the third step of Pandit's (1996) grounded theory research model. Research data was found using the databases Google Scholar, Research Gate, and Auburn University's online library database. Keywords used to search included "ICU", "healthcare", "interior design", "neuroscience", "neural systems", "transaction", along with a combination of several of these keywords. All data will be coded using the qualitative data software, NVivo. NVivo allows the user to import files into a project where it begins to categorize all data within a file, no matter its relevance.

Step four of Pandit's (1996) method asks for the researcher to analyze while categorizing data. To meet this step, findings and thoughts on the data will be recorded for each piece of data on a categorical chart. This step allows the study to be analyzed thoroughly and create a specific picture of the transaction between the neural system and the ICU that the researcher seeks to identify. The result of this step will include a chart that show key research findings of each piece of data.

After gathering all relevant and related published literature, articles will be filtered by reviewing for relevance to interior design, neuroaesthetics, architecture, or aesthetic experience. The literature revision section of the data sourcing process resulted in a significant decrease in data to be used within the study. Many eliminated articles focused on aesthetic suggestions for interior design, such as research articles that offer information for elements needed in a certain interior environment. Neuroscience that focused solely on architecture or abstract aesthetic meanings in architecture was also eliminated for the lack of relevance to the interior aesthetic experience. Along with these reasons, articles were also eliminated for general irrelevance. After filtering, 12 studies were deemed relevant to interior design, neuroaesthetics, or the aesthetic experience and were used in the research process.

To begin the coding process, data files were entered as a file into the NVIVO software. The researcher combined the open and axial coding process to comply with the NVIVO software algorithm. NVIVO requires the researcher to create major codes which can then be divided into child codes that fall within the subject category of the major codes. The major codes created are general topics used when filtering research. The three major category codes include interiors/interior design, neuroscience, and patient. These major codes were identified as general concepts that fall within the scope of this research. Major codes were then divided into child codes (content specific codes) with five child codes under interiors/interior design, four child codes under neuroscience, and four child codes under patient. Interior design child codes included aesthetics, healthcare, intensive care unit, interior environment, and spatial relations. Neuroscience child codes included neural processing, neural transaction, neuroaesthetics, and time response. Patient child codes included emotion, patient satisfaction, physical orientation, and state of mind.

Open Coding

The data analysis phase will begin with the open coding process. Open coding separates data into different units of meaning by conceptualizing and labeling data (Moghaddam, 2006). Pandit (1996) states that open coding is where the researcher begins to ask questions and make comparisons. The open coding process eliminates research bias by coding everything, regardless of relevance, to find as many codes as possible (Moghaddam, 2006; Giske & Artinian, 2007).

Codes may then be categorized around a related abstract theme for added structure (Moghaddam, 2006).

This study will use the qualitative software program, NVivo, as previously mentioned. After files are imported into NVivo, the researcher can begin to code common themes found within each file. More common themes identified will be shown in files folders. Smaller subcategories are organized underneath the common theme file folders based on relevance of the topic. Using NVivo, the open coding process will identify dozens of codes, including codes that would likely be missed if the coding process was performed by hand.

Axial Coding

Axial coding directly follows the open coding process. Open coding creates many different codes that will create many different subcategories, axial coding will reduce these subcategories into larger concepts that begin to form (Moghaddam, 2006). With the help of NVivo, the conceptual part of axial coding will be formed using codes and categorizing the imported data. Once categories are established, concepts will be explored in depth and analyzed for their strengths and weaknesses (Moghaddam, 2006). Conceptual analysis will provide justification for the emerging theoretical framework (Moghaddam, 2006). The categories formed can also be used to compare relationships across categories and subcategories, constructing a model for the occurrence of phenomena (Moghaddam, 2006).

Using NVivo, the categories formed from the conceptualization process begin to form relationships by topic. Relationships found across data will be logged into a relationship's category on the software. Once a relationship is created and logged with the appropriate data, a transcript with the appropriate information is visible with each corresponding relationship folder within the Nodes tab.

Selective Coding

The final part of step 6 is selective coding (Pandit, 1996). Selective coding is the process of narrowing categories and relationships down to determine to a core category and validating the relationships to the core category (Moghaddam, 2006). Selective coding should be conceptual and abstract in nature so the researcher can begin to develop a theory (Moghaddam, 2006; Giske & Artinian, 2007).

The major categories in NVivo found in axial coding will likely feature most of the conceptual theories needed for the selective coding process. To organize the concepts, the codes will be charted alongside the data information, shown in Table 3. This chart will make comparisons of concepts and relationships straightforward.

Table 3. ***Data Organization Chart*.**

Data	Open Coding	Axial Coding	Selective Coding

Theoretical Sampling

Theoretical sampling is the last part of the methodology process. After the completion of coding, the researcher will analyze the gathered data and will determine what data should be collected to fill gaps of information in each category (Pandit, 1996). Theoretical sampling will be conducted only for the purpose of justifying the proposed theory and the topics explored will be determined by the results of the coding process (Pandit, 1996). Sampling will also gather more information on conceptual topics and provide for developing propositions and properties (Pandit, 1996). The sampling process will conclude when the theory has sufficient theoretical saturation and upon the researcher’s discretion. The connections are explored using NVIVO diagramming software. This software models the relationship between two codes using data discussing both codes. The parent codes are shown in highlighted bubbles with related data articles branching off each. If the codes are related to both codes, they will have branches connecting to both parent codes. Through these branches, it can be determined if there is a relationship between the two parent codes.

Summary

This study will use a content analysis method of neuroscience and interior design research to investigate the transaction between an ICU patient's neural system and the ICU environment. The content analysis method is a qualitative method of study that involves gathering, processing, and analyzing data found within the research. This method is useful for this exploratory study of the connection between neuroscience and interior design research to connect the transaction between neural systems and the interior spaces. It is the goal, with the development of the coding process discussed previously, that the results of the coding process will lead to the development of grounded theory connecting neuroscience and interior spaces. The process of building a grounded theory will use the process outlined by Pandit (1996) and involves data collection, data ordering, open coding, axial coding, selective coding, and theoretical sampling. Following the development of the content analysis, interpretation of the data and discussion can commence.

CHAPTER IV

RESULTS

Results of the data sourcing method presented 32 potential research articles relevant to the study vetted by the researcher based on the abstract and title. To review, 12 studies were deemed relevant to interior design, neuroaesthetics, or the aesthetic experience and were used in the research process. The three major category codes include interiors/interior design, neuroscience, and patient. Major codes were then divided into child codes: interior design, neuroscience, and patient child codes. The results of this content analysis are reflected in the following chapter.

Coding

Figure 6 displays the hierarchy of codes between the 3 parent codes and 12 child codes developed during research underneath the main topic 'Neuroaesthetics in Healthcare Interior Design.' One child code 'intensive care unit' was not found within any of the data, therefore has been excluded from the following charts. Open codes are represented in light grey, axial codes are shown in black, and the selective code is shown in dark grey.

Figure 6. ***Code hierarchy chart***.

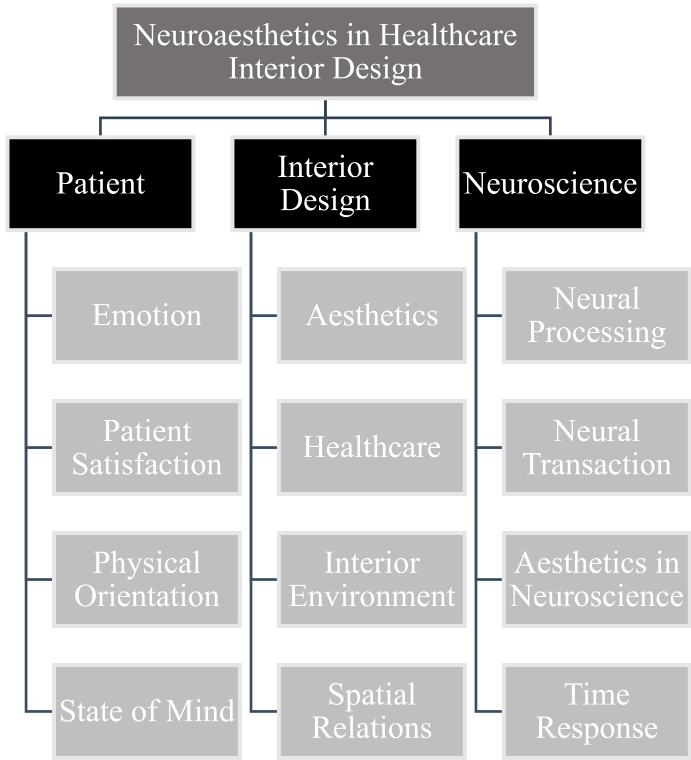


Figure 7 charts represent the code frequency identified within the research data. Each chart displays the frequency of references for every child code and their parent code. Interior design was referenced within architectural studies most often, with only one research study (Nanda, et al., 2009) focused on the impact of neuroscience on interior design formally. Interior design (55), interior environment (68), and aesthetics (64) child codes are substantial to the development of the grounded theory. Spatial relations (82) child codes were identified the most often, with most references discussing how a user processes their environment.

Neuroscience codes were also recorded for the relation to how a user experiences the environment and how the environment interacts with the user's mind. The cohort of data used in this study were based on neuroscience studies making neuroscience the most common topic among the data. Within the neuroscience codes, the neuroscience (154) child code was referenced the most but neural processing (115), neuroaesthetics (84) and neural transaction (57) also reported substantial findings. Lastly, the time response (3) child code was not found to be substantial to the development of the ground theory.

Patient codes were also recorded and were the least referenced of the three parent codes. Patient (18), emotion (26), and physical orientation (15) were the only codes under the patient parent referenced a considerable amount of times. State of mind and patient satisfaction were mentioned a total of 3 times, therefore, these codes are not considered substantial to the development of the grounded theory.

Figure 7. ***Code Frequency Chart A*.**

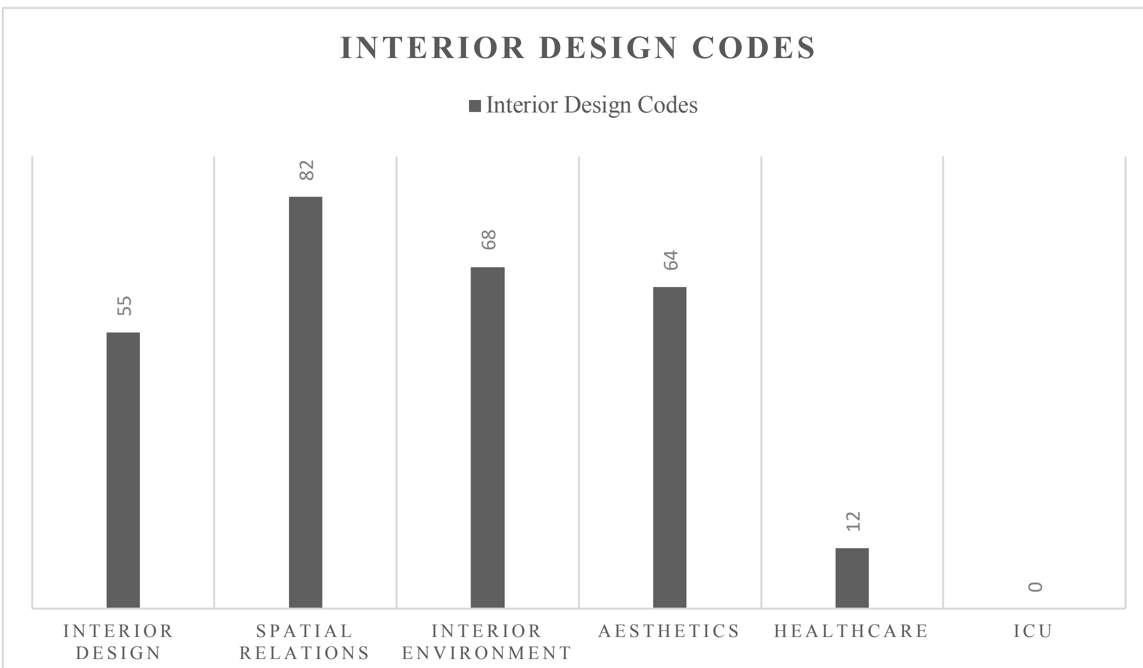


Figure 7. ***Code Frequency Chart B***.

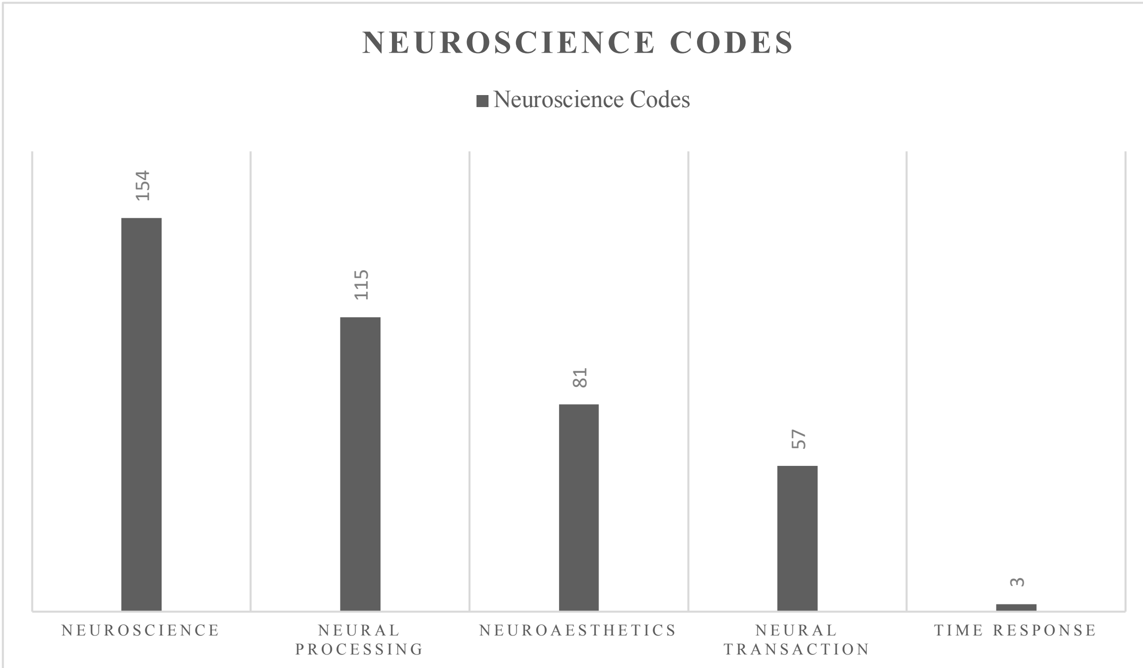


Figure 7. ***Code Frequency Chart C***.

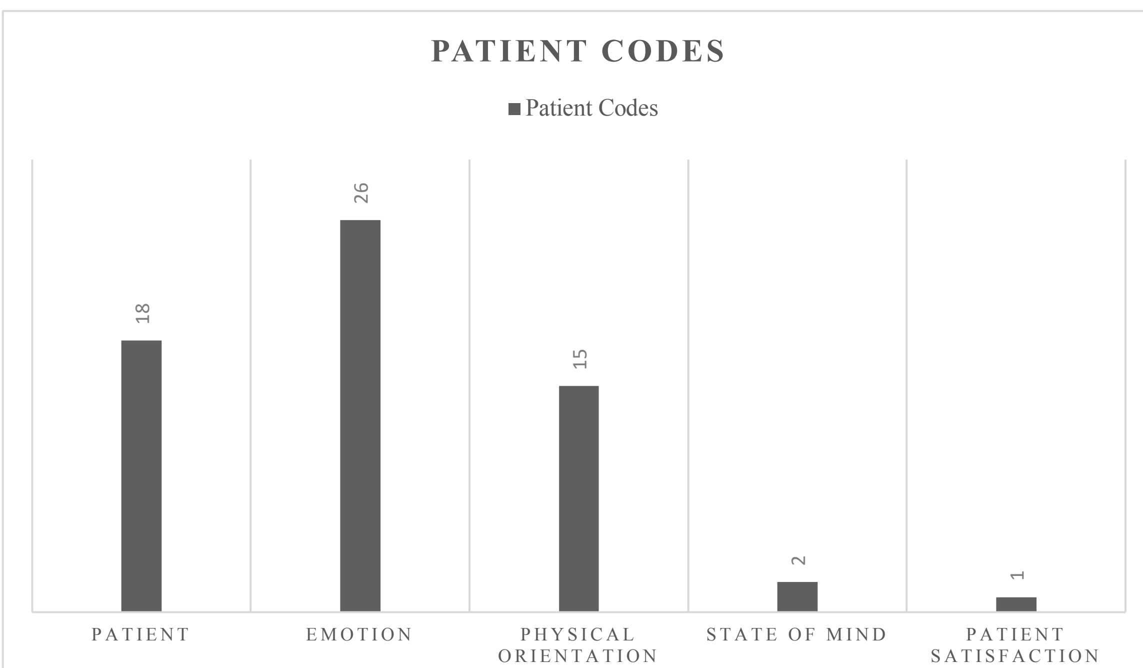


Table 4 displays the organization chart discussed on page 31 completed after the coding process was complete. The chart demonstrates the codes referenced in each article. Child codes are represented in the open coding column, parent codes are represented in the axial coding column, and selective coding reads 'neuroaesthetics in healthcare interior design' to correlate the main concept behind this study.

Theoretical Sampling

A final check for data was conducted using the same method previously used. After a second thorough search, no relevant data was discovered that was not previously used in the first data search. To sufficiently saturate the connection between interior design and neuroaesthetics, the connection between interior design and neuroscience, neuroaesthetics and neuroscience needs to be defined more clearly. The connections are explored in Figure 8 and Figure 9 using NVIVO diagramming software. NVIVO models connections using relationship diagrams with the parent code in yellow and with branches for data that show a significant correlation to a parent code. Codes that are not correlated to both parent codes are displayed through a singular connection.

Figure 8. ***Interiors or Interior Design/Neuroscience Relationship Diagram (modeled in NVIVO).***

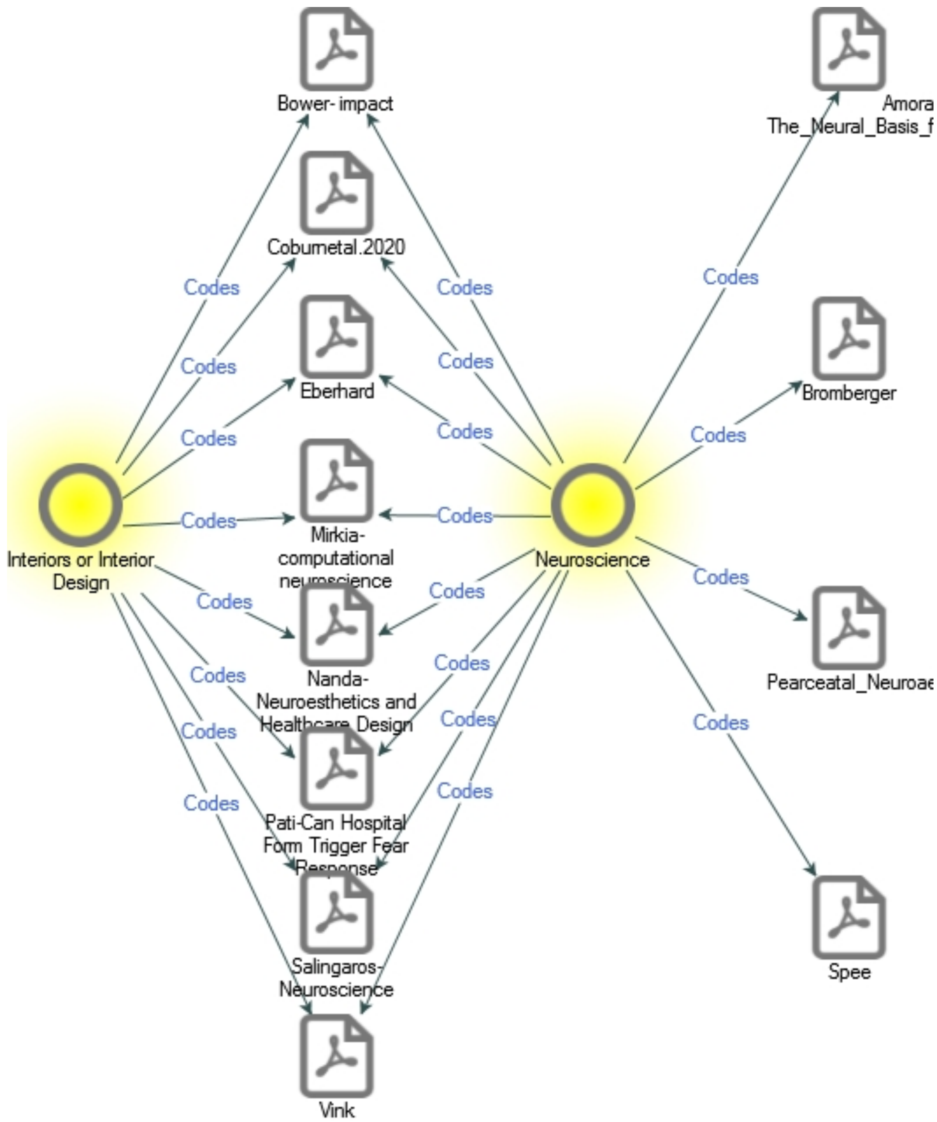


Figure 8 displays the relationship between interiors or interior design parent code and neuroscience parent code. Each piece of data used in Table 4 was modeled in this diagram with significant correlations modeled with two connection lines. Amorapanth, et al. (2010), Bromberger, et al. (2011), Pearce, et al. (2016), and Spee, et al. (2018) are significantly correlated to the neuroscience parent codes but are not found to be correlated to the interiors or interior design parent code. Bower, et al. (2019), Coburn, et al. (2020), Eberhard, J. P. (2009), Mirkia, et al. (2012), Nanda, et al. (2009), Pati, et al. (2016), Salingaros, et al. (2008), and Vink, et al. (2016) were all found to be significantly correlated to the interiors or interior design parent code and the neuroscience parent code.

Figure 9. ***Neuroscience/Neuroaesthetics Relationship Diagram (modeled in NVIVO).***

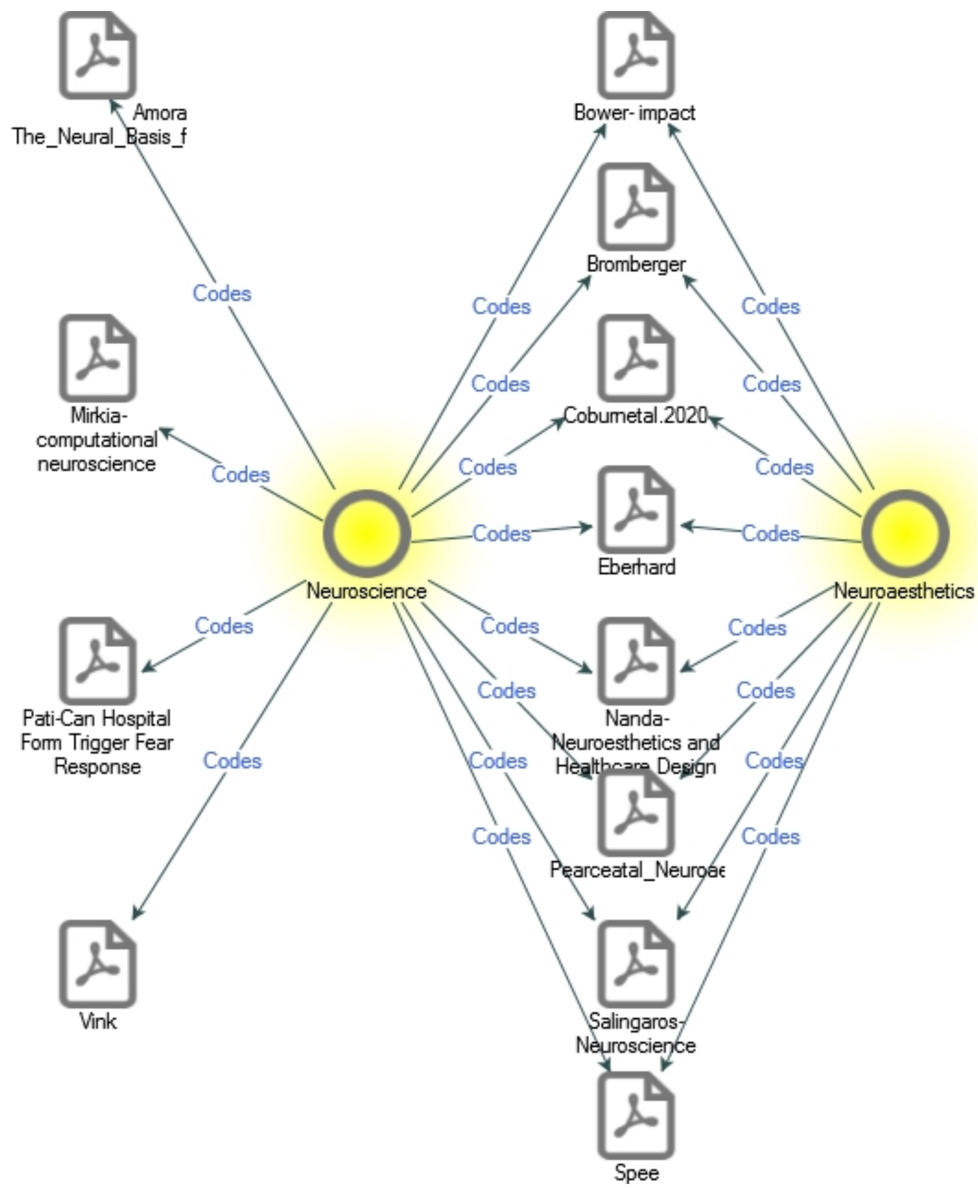
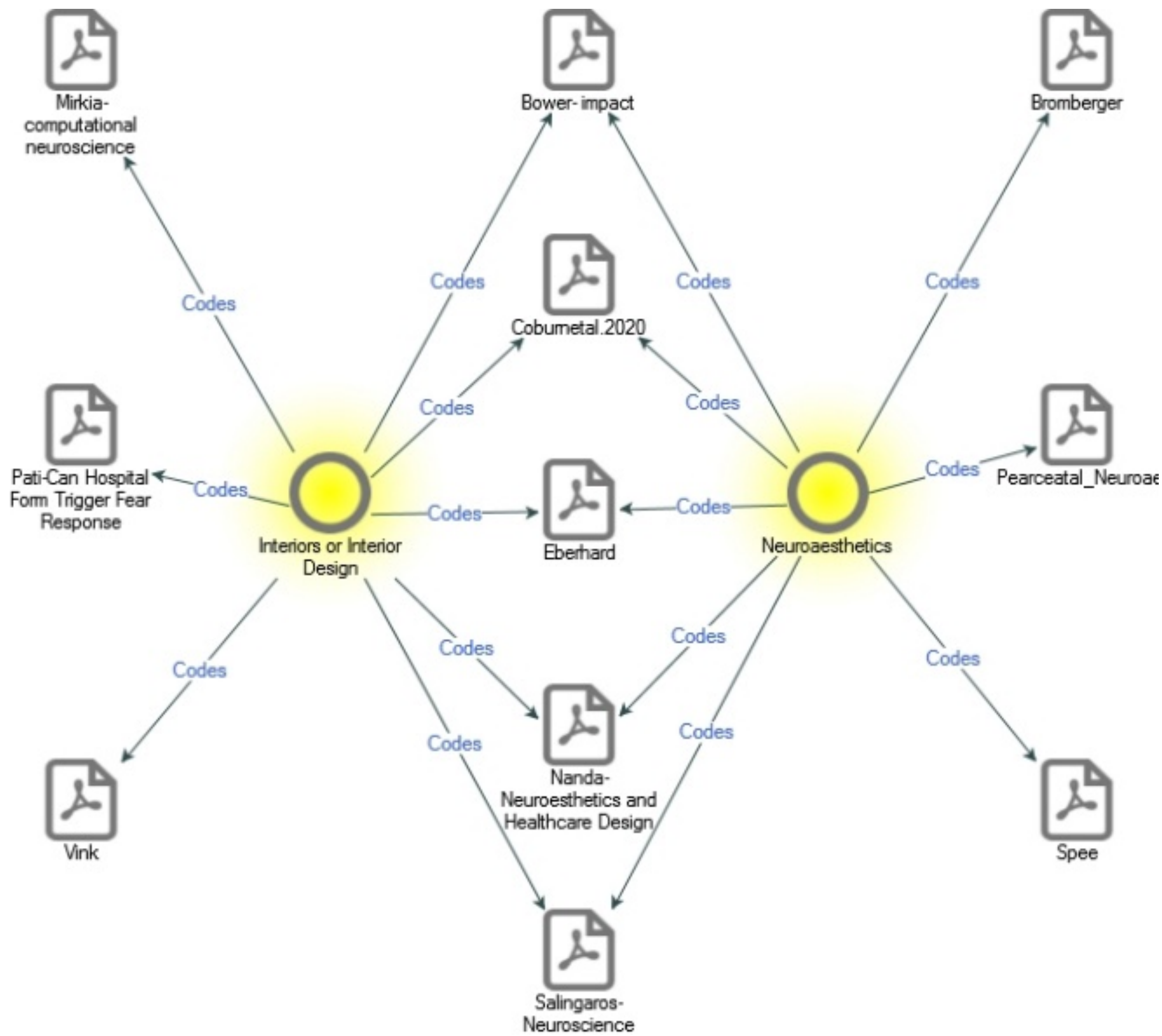


Figure 9 displays the relationship between the neuroscience parent code and neuroaesthetics parent code. Amorapanth, et al. (2010), Bromberger, et al. (2011), Pearce, et al. (2016), and Spee, et al. (2018) are significantly correlated to the neuroscience parent codes again but are not found to be correlated to neuroaesthetics parent code. Bower, et al. (2019), Coburn, et al. (2020), Eberhard, J. P. (2009), Mirkia, et al. (2012), Nanda, et al. (2009), Pati, et al. (2016), Salingaros, et al. (2008), and Vink, et al. (2016) were all found to be significantly correlated to the neuroscience parent code and the neuroaesthetics parent code.

Figure 10. ***Interiors or Interior Design/Neuroaesthetics Relationship Diagram (modeled in NVIVO).***



As shown in the above figures, 8 of the 12 research studies were found to link interior design and neuroscience and neuroaesthetics and neuroscience. Shown in Figure 10, Bower, et al. (2019), Coburn, et al. (2020), Eberhard, J. P. (2009), Nanda, et al. (2009), and Salingaros, et al. (2008), were found to be correlated to the interiors or interior design parent code and the neuroaesthetics parent codes. This correlated data provides evidence for a direct correlation for interior design and neuroaesthetics. Figure 10 serves as the final model of the data analysis phase (step 8 reaching closure) of Pandit's (1996) study of how to build grounded theory.

Conclusion

This chapter revealed the results of the coding and theoretical sampling process. Codes were first identified and recorded for frequency within the data. Interior design codes, shown in Figure 7 Chart A, were the most substantial recorded topics, as expected, with spatial relations (82), interior design (55), interior environment (68), and aesthetics (64) child codes. Neuroscience codes, shown in Figure 7 Chart B, were also mentioned frequently throughout the cohort of data. The neuroscience (154) child code was referenced the most but neural processing (115), neuroaesthetics (84) and neural transaction (57) are all found to be significant within the data. Patient codes, shown in Figure 7 Chart C, were less substantial in this cohort, with patient (18), emotion (26), and physical orientation (15) child codes being recoded, but still provide useful information.

The data in Table 4 disclosed the codes recorded for each article during the open, axial, and selective coding process. Open coding allowed for 15 topics (codes) to be revealed within each article. Axial coding narrowed topics into parent codes, interiors or interior design, neuroscience, and patient, that was generalized in selective coding to become "neuroaesthetics in healthcare interior design." Overall, the coding process helping to identify codes required to conduct theoretical sampling.

Finally, theoretical sampling, the final step of Pandit's (1996) grounded theory process, was used to reveal a connection between the interiors or interior design parent code and the neuroscience parent codes (Figure 8), the neuroscience parent code and the neuroaesthetics parent code (Figure 9), and the interiors or interior design parent code and the neuroaesthetic parent codes (Figure 10). Figure 8 showed that Bower, et al. (2019), Coburn, et al. (2020), Eberhard, J. P. (2009), Mirkia, et al. (2012), Nanda, et al. (2009), Pati, et al. (2016), Salingaros, et al. (2008), and Vink, et al. (2016) were all found to be significantly correlated to the interiors or interior design parent code and the neuroscience parent code. Figure 9 showed that Bower, et al. (2019), Coburn, et al. (2020), Eberhard, J. P. (2009), Mirkia, et al. (2012), Nanda, et al. (2009), Pati, et al. (2016), Salingaros, et al. (2008), and Vink, et al. (2016) were all found to be significantly correlated to the neuroscience parent code and the neuroaesthetics parent code. Finally, Figure 10 showed that Bower, et al. (2019), Coburn, et al. (2020), Eberhard, J. P. (2009), Nanda, et al. (2009), and Salingaros, et al. (2008), were found to be correlated to the interiors or interior design parent code and the neuroaesthetics parent codes. These five articles will be used within the final data set used to build the grounded theory between the connection of neuroaesthetics and interior design.

CHAPTER V

DISCUSSION

Ch. 4: Results revealed the connection between interior design and neuroaesthetics. The use of neuroaesthetics in interior design may have been observed within interior design and neuroscience research. Conclusions from the data were made through the data ordering and data analysis phases of Pandit's (1996) 'process of building grounded theory.' The final step of the process is the literature comparison phase where conflicting and similar frameworks can be compared to the emergent theory. This chapter will expand on the results found in Chapter 4 and complete the final step to Pandit's (1996) grounded theory method and use critical analysis to evaluate similar and contradictory frameworks. Lastly, an introduction to the theory and future research will be discussed.

RQ1: *Is there a phenomenon between neuroaesthetic response and the ICU environment?* A phenomenon between neuroaesthetics and interior design was suggested in Figure 10. After the coding exercise, five articles were found to correlate neuroaesthetics to interior design. Intensive care unit research possibly has not, currently, used neuroaesthetics to influence interior design based on the knowledge of this research. A connection between neuroaesthetics and general interior design may lead to the assumption of an existing phenomena between neuroaesthetic response and the ICU environment.

RQ2: *What research exists regarding neuroaesthetics and the ICU environment?* Research between neuroaesthetics and the ICU environment was not suggested within the guidelines of this research. Research exploring neuroaesthetics, the ICU, and healthcare interior design were used to explore more general phenomena between neuroaesthetics and interior design.

RQ3: *Can assumptions be made from research regarding the ICU environment and neuroaesthetics?* A connection between neuroaesthetics and interior design (displayed in Figure 10) establish a phenomenon between neuroaesthetics and interior design. It can be assumed that there is a phenomenon between the ICU environment and neuroaesthetics based on this discovery and on the assumption that all interior design would create a neuroaesthetic response within the brain.

Literature Comparison

To complete Pandit's (1996) theory building model, conflicting and similar research may help explain multiple viewpoints of the findings and how they relate to the research questions and the building theory.

Conflicting research

Finding conflicting research to this proposed study is difficult. There may have been no studies that directly focus on the use of neuroaesthetics in healthcare interior design and only a few studies to make comparisons to architecture and interior design. The lack of research means that there may have been no studies that have challenged the use of neuroaesthetics in interior design. There has, however, been a couple criticisms for neuroaesthetics as a whole and how the study needs to evolve.

Martin Skov's (2009) study evaluated the major issues within the emerging field of neuroaesthetics to capsulate major areas of improvement for the field. The biggest issue, she says, is that there is not a clarified model for how to evaluate aesthetics and artworks (Skov, 2009). The un-proposed model Skov (2009) is specifically mentioning evaluates art pieces so researchers can clearly evaluate how the brain processes beauty, which is still relevant to general aesthetic evaluation, such as interior design. Since art is extremely subjective, existing research has struggled. Skov (2009) also discusses the lack of grammar of how aesthetic appreciation is commuted in the brain, meaning clarification is needed for how and what is being used during aesthetic evaluation. Skov (2009) uses these criticisms to push the field to develop further research. This study pushes Skov's (2009) criticisms directly using content analysis to create a similar model to what Skov (2009) is suggesting. Skov (2009) is specifically asking for neuroscience studies of what parts of the brain evaluate art, how to perceive art, and how to make neuroscience research repeatable to push the field of neuroaesthetics further. While this study is not a neuroscience study, it does create a connection for how we can connect neuroaesthetics to interior design, expanding upon the existing field of research.

Nadal and Pearce (2011) also published criticisms for the field of neuroaesthetics, previously presented at the 2011 Copenhagen Neuroaesthetics conference. Their first concern involves the concern for how and where neuropsychological and neuroimaging results converge and how to relate their purposes to each other (Nanda & Pearce, 2011). Neuropsychological studies tend to focus on degeneration or production of art pieces while neuroimaging studies focus on where the brain processes aesthetic information (Nanda & Pearce, 2011). Their relationship and how they are similar needs to be clarified in future studies. Perhaps most relevant to this study, Nadal and Pearce (2011) agree with other criticizers that neuroaesthetics does not have a proper subject matter established and argue that neuroaesthetics should solely focus on aesthetic experience in the brain. This opinion also discredits research that focuses on aspects of art and other aesthetic features saying it cannot properly identify these elements (Nadal & Pearce, 2011). If this statement was considered true, the use of interior design in neuroaesthetics would be limited to how a person experiences the space. It would discredit any future neuroaesthetic research into particular elements of a space that evoke emotion and create different aesthetic experiences. From the viewpoint of this study, this study would fit within the realm of neuroaesthetics evaluating aesthetic experience, would limit neuroaesthetics to overall experience, and would limit future use of the theory being proposed at the end of this chapter.

Similar frameworks

Although there are not specific conflicting frameworks to the building theory, there are several frameworks that could be argued as similar or related to this research and could be built upon in the future. This section will compare frameworks to the building theory, but also highlight their differences, establishing a need for the new theory. The transactional model of stress and coping was used within this study to provide an outline for the transaction process between the brain and the ICU establishing a need for a formal connection between neuroaesthetics and interior design as a necessity to properly study the connection between the brain and the ICU interior environment in future studies. Since this theory has already been discussed at length in this study, it will be excluded from this section as a similar framework.

When searching for similar frameworks, Gomez-Puerto, Munar, and Nadal's (2016) framework defining the *preference for curvature in aesthetics* presented itself. Their framework is similar to some neuroaesthetics studies because they have possibly identified a biological preference for curved lines (Gomez-Puerto, Munar, & Nadal, 2016). It is also notable that both use aesthetic studies to identify patterns in biological preferences (Gomez-Puerto, et al, 2016). While this framework could be useful for specific studies in neuroaesthetics in the future, it does directly identify this aesthetic preference as neuroaesthetics. It also does not identify interior design or architectural curved lines in particular.

A well-known theory relatively similar to the theory being built is *behavior setting theory*. Roger Barker (1963) created the theory in 1963 to describe and explain how humans interact within small social systems and within a known environment (Popov & Chompalov, 2012). Behavior setting theory establishes meanings and patterns to what individuals may do instinctually or habitually based on meaning or context established from societal and personal norms (Popov & Chompalov, 2012). Within interior design, this theory can be used to establish patterns for how individuals may use a space or establish a meaning to an object. This theory is similar to the theory being built because it examines how a user may evaluate and use a space (Popov & Chompalov. 2012). This theory does not cover the neuroscience aspect of the user-environment relationship, but focuses on the psychology of why patterns may form (Popov & Chompalov, 2012). Therefore, the building theory looks deeper into the biological interaction than behavior setting theory does and specifically relates to interior design, which behavior setting theory does not (Popov & Chompalov, 2012).

The final theory worth noting for its similarity is *place identity theory*. Place identity establishes the connection between individual and place and examines the connection between physical environment and the development of one's identity (Bernardo & Palma- Oliveira, 2014). Many studies of place identity have focused on how the physical environment makes different social systems interact with spaces differently and how the identity with a place develops (Bernardo & Palma- Oliveira, 2014). In interior design, place identity is useful to determine how social systems interact with different objects or architecture and developing plans for how the environment can best serve the type of user within a space and many interior design studies have completed similar studies (Bazuin, & Cardon, 2011; Brinkmann, et al., 2018; Charles, et al., 2017; Fontaine, et al., 2001; Hupcey, 2000; Pati, et al., 2016; Salonen, et al., 2013; Ulrich, 2001). Place identity is different than the building theory because it does not focus on the connection of neuroscience and the incorporation of interior design. Although studies have used this theory to examine interior environments, place identity establishes connection with place but does not examine the actual design and why a connection or reaction is formed within the brain (Bernardo & Palma- Oliveira, 2014).

The previous frameworks are not the only theories similar to this research in existence, but they are three frameworks that are similar enough to be used as a reference to build this theory. The examination of the previous framework has provided more insight to the language to stating a theory and the insight needed for how to use the theory.

Relationships

The relationships established from the research need to be explained in more detail to better understand the significance of the findings and how the findings relate to this study's research questions. The similar frameworks discussed in the previous section and the codes used within the NVIVO research can help to explain the phenomena found within each relationship.

Neuroscience/Neuroaesthetics Relationship

A phenomenon established between neuroscience and neuroaesthetics was possibly established in Figure 9. As previously mentioned, Bower, et al. (2019), Coburn, et al. (2020), Eberhard, J. P. (2009), Mirkia, et al. (2012), Nanda, et al. (2009), Pati, et al. (2016), Salingaros, et al. (2008), and Vink, et al. (2016) were found to be significantly correlated to the neuroscience and neuroaesthetics parent codes.

Neuroscience and neuroaesthetics are connected through the study of the brain and the nervous system. Neuroaesthetics is considered a form of neuroscience generalized towards the study of how the brain processes aesthetics. A connection between the two topics can be established through definition alone but, to further explore this relationship research child codes found to be related to neuroscience can be used, as shown in the Code Hierarchy Chart (Figure

6). Along with these child codes, Figure 9 suggests an established connection between these two parent codes in all twelve child codes used with the coding exercise. Using Figure 9 and Table 4 (shown in Appendix I), assumptions can be made about the neuroscience/neuroaesthetics relationships.

Neural processing is the core of how the neuroscience and neuroaesthetics are related. Neural processing is, generally, how the brain processes anything to make a human body function including movement, thoughts, organ function, etc. Neuroscience studies neural processes and how the brain and central nervous system create and maintain human functions. Neuroaesthetics focuses on the aesthetic processing part of the brain and nervous system functioning (Chatterjee, 2010). Aesthetic evaluation and response require a form of neural processing within the brain (Chatterjee, 2010). All twelve research items in the exercise were related to neural processing, with eight closely related to the neuroaesthetic/neuroscience relationship. Figure 9 and Table 4 create a link between the use of neural processing within neuroscience and neuroaesthetics. Based on this finding, it can be suggested that neuroscience and neuroaesthetics use human body functions as measures to develop research.

Spatial relations are a neural function resulting from neural processing within the brain. Spatial orientation is compartmentalized within the parietal and occipital lobes (Nanda, Pati & McCurry, 2009). These two lobes allow the body to interact with its surroundings, connecting the brain to its environment (Nanda, Pati & McCurry, 2009). During the code hierarchy exercise, eight of twelve research articles were coded in relation to the spatial relations child code. For neuroscience, orienting space falls within the category of brain functioning. Neuroaesthetics in interior design uses spatial relations to orient an individual within a space, allowing the user to determine how to interact with their surroundings. Essentially, the neuroscience and neuroaesthetics relationship explains how spatial relations is used to process and interact with an individual's immediate surroundings.

Physical orientation was another child code used within the code hierarchy exercise. Five of twelve research articles were found in relation to physical orientation. This code is a simpler form of spatial relations where an individual physically orients themselves in an environment, but does not necessarily interact with the environment. Neuroscience and neuroaesthetics studies are very similar in definition to the broader code of spatial relations. The presence of physical orientation discussions in neuroscience and neuroaesthetics creates another link between the two parent codes.

The neuroscience/neuroaesthetic relationship does not provide specific evidence for any of the research questions but adds to the growing list of research avenues available to neuroaesthetics, interior design and the ICU environment. Research question one asked whether there was a phenomenon between neuroaesthetic response and the ICU environment. This relationship does not answer that question, instead, this relationship suggests a connection between related topics. This relationship is the first step to establishing a direct correlation between neuroaesthetics and interior design in future research. Establishing the topical connection between the study of the brain (neuroscience) and the study of the how the brain processes aesthetics (neuroaesthetics) suggests a grounding for the use of neuroscience studies in interior design. Although topical connections are suggested, there is not enough evidence to assume that any research questions proposed in this study can be answered by the neuroscience and neuroaesthetics relationship.

Neuroscience/Interiors or Interior Design Relationship

The phenomena between neuroscience and interior design was established in Figure 8. This relationship is not as closely related in topic as the previous relationship, so requires more research-based connections to explain. As previously mentioned, Bower, et al. (2019), Coburn, et al. (2020), Eberhard, J. P. (2009), Mirkia, et al. (2012), Nanda, et al. (2009), Pati, et al. (2016), Salingaros, et al. (2008), and Vink, et al. (2016) may have been found to be significantly correlated to the interiors or interior design/ neuroscience relationship. Of the eight child codes between the interior or interior design and neuroscience parent codes, two child codes, physical orientation and spatial relations, are the most beneficial codes to explain this relationship.

Physical orientation can be further explained in Figures 4 and 5. These two figures display how the brain, mainly, orients space through the occipital and parietal lobes (Rehman & Al Khalili, 2020; The Human Memory (a), 2020; Westen, 1996; *Society of Neuroscience*, 2006). Neuroscience studies that focus on orienting space in the immediate environment can easily be connected to how humans physically orient their body within an interior space. Design methods, such as grouping or color coding, can help the individual determine how to physically use the space. When designing, the designer thinks about how the user will occupy the space. The physical orientation child code directly links neuroscience and interiors or interior design relationship through the body/interior environment relationship.

Spatial relations, similar to physical orientation, is also helpful. As explained previously, spatial relations go a step beyond physical orientation in that the individual creates a relationship with the space. A simple example is the relationship between the individual and their home or work. The spatial relations child code explains how the brain relates to the interior environment. The parietal and occipital lobes register the environment and actions surrounding the body and neurons respond with how to interact (Nanda, Pati & McCurry, 2009). Neuroscience and interior design may directly relate how the space speaks to the brain.

This relationship goes a step further in establishing the connection between neuroaesthetics and the ICU environment, as questioned in research question one. The connection between neuroscience and interior design, like the previous relationship, still does not answer the whether there is a phenomenon between neuroaesthetics and the ICU environment. This relationship may create a precedent for the connection between the study of the brain and interior environments, which can be used for many future studies on any type of interiors. Since research question one is not answered, it can be assumed that research questions two and three are not answered by this relationship as well.

Neuroaesthetics/Interior Design Relationship

The phenomena between neuroaesthetics and interior design was suggested in Figure 10 and is the most important relationship established from this study. The neuroaesthetics, being similar to neuroscience, and interior design relationship share similar relationship explanations as the neuroscience and interior design relationship. In Figure 10, Bower, et al. (2019), Coburn, et al. (2020), Eberhard, J. P. (2009), Nanda, et al. (2009), and Salingaros, et al. (2008), were possibly found to be related to the interiors or interior design/neuroaesthetics relationship.

The aesthetics code explains the neuroaesthetics and interior design relationship closely. Neuroaesthetics is, by definition, the science of aesthetic evaluation (Chatterjee, 2010). The aesthetic code used in this study, therefore, directly relates to aesthetics. Aesthetic evaluation in neuroscience is controlled, primarily, through the occipital lobe in the cerebral cortex (Amorapanth, et al., 2010; Barrett & Satpute, 2013; Bromberger, et al., 2011). The brain develops patterns for preferred aesthetics that has begun to be studied in neuroscience research

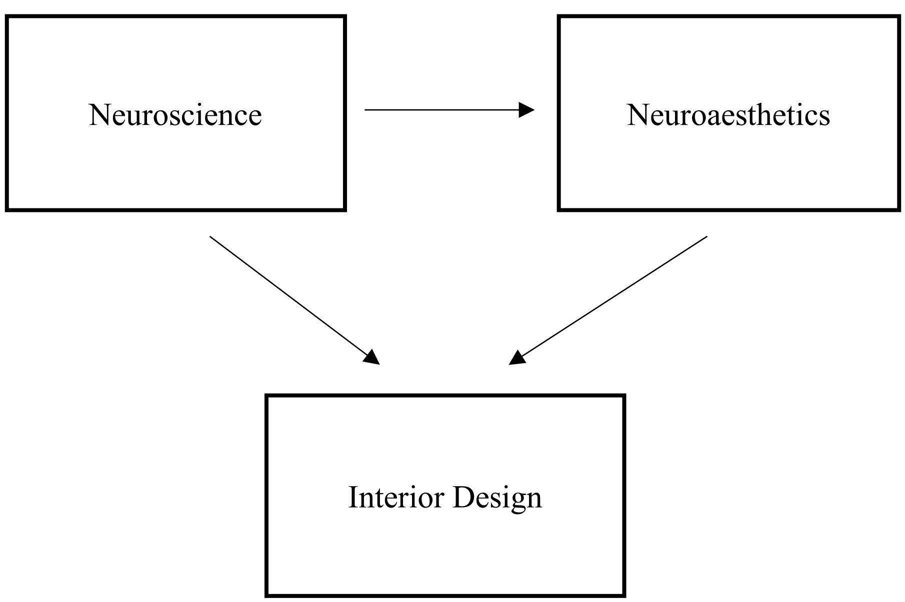
(Bower, et al., 2019; Bromberger, et al., 2011; Chatterjee, 2003; Eberhard, 2009; Mirkia, et al., 2012; Pearce, et al., 2016; Salingaros & Masden, 2008). Aesthetics is interior design is based through creativity of the designer and established aesthetic styles and preferences of the user (Bazuin & Cardon, 2011; Cesario, 2009). Creativity and design are part of aesthetic evaluation processed in the occipital lobe, as well as other parts of the brain (Bazuin & Cardon, 2011; Cesario, 2009). Aesthetics can be explored in the interior design/neuroscience relationship for the differences in environment can have on the brain.

Neural transaction between the brain and the environment is a large part of neuroaesthetic studies and can be extended to the study of neuroaesthetics in interior design (Chatterjee, 2010; Nanda, et al., 2009). Essentially, neural transaction may be the connection between the brain and interior design. Four research articles may have been found to be related to neural transaction during the coding hierarchy exercise. Similar to spatial relations, the neural transaction explores how the human brain interacts with its environment. The brain processes surroundings using the parietal and occipital lobes and uses neurons to explain and respond to the aesthetics of an object or space.

The interior environment child code needs significant exploration in the future. Interior environment, related to neuroaesthetics and interior design, was only suggested to be related to one article in this study. As previously discussed in Chapter 2, Nanda, Pati, & McCurry (2009) studied the connect between neuroaesthetics and healthcare interior design. Their research explores comparisons between the two topics using visual elements and principles and aesthetic response (Nanda, et al., 2009). Principles like peak shift effect (appreciation of exaggerated shapes), isolating a single cue, perceptual grouping, contrast, using visual metaphors, and symmetry all contribute to how a user may experience a healthcare environment (Nanda, et al., 2009). Aesthetic preference in design is a topic that needs to be explored further in neuroaesthetic studies, but aesthetic preferences of art can be applied to interior design to easily explore the relationship between interior design and neuroaesthetics.

The neuroaesthetics and interior design relationship comes close to answering research question one where a phenomenon between neuroaesthetics and the ICU environment is questioned. As discussed above, the brain creates an aesthetic response to an interior environment, such as the ICU. Although assumptions still cannot be made due to the lack of direct correlation, this relationship comes close to answering research question one. Research questions two and three also cannot be answered with this relationship, but five research studies were suggested to connect neuroaesthetics to interior design. The neuroaesthetics and interior design relationship does suggest a precedent for more research into the connection between neuroaesthetics and the ICU environment, as well as many more interior environments.

Figure 11. *Relationship Diagram.*



Theory Proposal

The process of building a grounded theory has been continually building over the last two chapters. This research has followed Pandit's (1996) theory process (previously shown in Ch. 3) directly, with the comparison of frameworks being the last part of the process. From here the theory is ready to be presented, but, first, the following table is a summary of the process leading to the proposal.

Table 5. ***Theory Building Review (Based on Pandit's (1996) theory building process).***

Research Design Phase	
Step 1: Review of technical literature	Research questions and scope are defined
Step 2: Selecting cases	Theoretical framework is established and literature review is completed.
Data Collection Phase	
Step 3: Develop rigorous data collection protocol	Databases are used to gather data and filtered through for the final 11 research articles.
Step 4: Entering the field	Research articles are entered into NVIVO and sorted for relevance for the final 11 articles.
Data Ordering Phase	
Step 5: Data Ordering	Data is organized to make sense with the research (alphabetical and into major subject categories).
Data Analysis Phase	
Step 6: Analyzing data relating to the first case	Open, axial, and selective coding was used. Results are shown in Table 4.

Step 7: Theoretical sampling	Final database check is completed and diagrams are modeled in Figures 8-10.
Step 8: Reaching closure	Diagrams are interpreted with a conclusion that creates a connection between interiors or interior design and neuroaesthetics.
Literature Comparison Phase	
Step 9: Compare emergent theory with extant literature	Conflicting and similar frameworks were explored.

Proposed theory

This study aimed to explore the relationship between neural response and the ICU interior environment. The objectives set out to explore neural response and the ICU, and patient psychological health when responding to ICU interior design. The study began with content research that included the exploration of the current known connections between neuroscience and interior design. Content research also established a lack of research into neural response and the ICU, with no found studies directly correlating patient response and interior design. This led to the idea that a connection needs to be established between neuroaesthetics and interior design. Because of the lack of studies discovered, a content analysis exercise was used to explore similar connections. The content analysis exercise used Pandit's (1996) theory building chart (reviews in Table 5) to begin to establish a grounded theory for future research into the neuroaesthetics and interior design connection. Previously explored in this chapter were the established relationships found during the content analysis exercise which include the neuroscience/neuroaesthetic relationship, the neuroscience/interiors or interior design relationship, and the neuroaesthetics/interiors or interior design relationship. The possible establishment of these relationships allowed for the assumption of a connection between all three parent codes and the connection between neuroaesthetics and interior design. The relationship findings were also compared to the original research questions asked at the beginning of the study. None of the research questions were specifically answered by the results of this study. Because there was no significant correlation between neuroaesthetics and the ICU environment, the development of a theory was found to be useful to the future of neuroaesthetic research.

The finalization of Pandit's (1996) grounded theory building chart and the connections defined between neuroscience, neuroaesthetics, and interior design allow for the theorization of a connection between neuroaesthetics and interior design.

Neuro-Interior Response Theory

This study proposes the *neuro-interior response theory* which is a suitable framework for the development of understanding how the brain responds to different aesthetics within interior design. Neuro-interior response theory is a framework suggested for the development of science in interior design. The proposed theory unifies the work of previous authors who have applied neuroscience or neuroaesthetics to architecture or interiors. Interior design studies have long known that aesthetics and human behaviors have defined how interiors are designed. The premise that humans connect to their environment is a topic that has been studied by many researchers, including the cohort of data used within this study. Neuro-interior response theory expands on that and identifies that the connection between human and interior environment comes from within the parietal and occipital lobes within the brain. A theory in neuro-interior response is advantageous because it allows the establishment of a subdivision of neuroaesthetics to be formed using only interior design. Further, the goal for future interior design research would be to use neuro-interior response theory as a ground to establish significance.

The development of neuro-interior response theory may also expand on the current small amount of research published into neuroaesthetics. This field of study serves as a branch of neuroscience research that has only been studied within the last two decades. Neuroaesthetics has been used to define how the brain establishes beauty standards from art to the human form. Only Nanda, Pati, & McCurry (2009) have made the jump from neuroaesthetics in art to neuroaesthetics in interior design. This theory suggests a direct connection between neural response and interior design that will allow research to further develop in the field of neuroaesthetics. This neuro-interiors subset of research can use many avenues of research in every type of interior design to explore meaning in interiors and create expressive environments for users.

In regards to how this study began, the goal was to explore neural response to the ICU environment and the existence of neuroaesthetic research related to the ICU environment. Although no studies were found relating neuroaesthetics to the ICU, neuro-interior response theory can be useful in future studies on this topic. Through typical interior design research, studies may be conducted to determine preferences of users within a space. For ICU design, these types of studies extend to many types of users within the environment such as the patient, multiple types of employees, and patient families. ICU design has become loosely standardized over years of developmental research into comfortable and efficient environments to optimize patient health. Neuro-interior theory can explore the neural response of all types of users and uses for the ICU environment to continue working towards the ideal space for ICU patient healing.

The broader impact of the neuro-interior response theory is not only the connection between neuroaesthetics and interior design, but how the connection can help interior design create healing, impactful designs. Neuro-interior research can leave a large gap in interior design research that has not been explored yet. The development of this theory sets a grounding for research that focuses on what the brain wants and reacts to, instead of spaces that may be built solely on things like opinion, technological developments, or trends. This theory can be used to focus on many different design aspects like line, form, and aesthetics functions that can play a role in the overall effect of a space. It is the hope that the neuro-interior response theory can expand how design views supportive environments. For the ICU, the neuro-interior response theory can be used to ground many different avenues of research that can take ICU's from distant, technology-forward spaces to spaces that evaluate patient needs and encourage healing within the environment. It is the hope that the neuro-interior response theory can help research evaluate how patient brains function during times of trauma and stress. Developments in design can help lead to more supportive environments for all types of interior design and it is the hope of this study that the neuro-interior response theory can help achieve this ultimate goal.

Limitations

There are several limitations to consider in this study. The implementation of this study was conducted by one researcher, which should be considered. The major limitation of this study is the lack of previous studies in the research area. Neuroaesthetics is a newer section of neuroscience that has a limited amount of published research. Although the topic is growing, the lack of knowledge in this field should be considered. Neuroaesthetics in interior design is even less explored which should be greatly considered when examining the results of this study and neuro-interior response theory. This study used multiple different data servers to explore articles, but some research avenues were left out. This may include any sources that require monetary contributions including card payments, subscriptions, or any decentralized digital currency. NVIVO was used as the sole source of coding in this study. Although unlikely, NVIVO could draw conclusions that are, possibly, not correlated. The use of NVIVO could also be flawed by the application of the data input into the program. Lastly, this study was conducted over a two-year period of time which could result in new data on the topic being published in the time frame. This two-year period also included societal conflicts that could inhibit the final result explanation. This study first began in January of 2020, right before the beginning of the COVID-19 pandemic. Initial methods for this study had to change due to location issues and was adapted accordingly. Societal conflicts also caused a delayed timeline and submission which should also be considered.

Future Research

After considering all disclosed limitations, consider the future exploration of this study. This study establishes the neuro-interior response theory that can be used in many ways in the future. The biggest opportunity for neuroaesthetics and neuro-interiors in the future is establishing why the human brain makes aesthetic associations. Future research should evaluate why the brain processes mood and style in an interior environment and how different interior environments affect stress and emotions in the brain. Along with each of these broad areas of neuro-interior research, specific areas can be explored with different sexes, races, ages, etc. Neuroaesthetics should research further into how the neuro-interior response theory can help understand visual communications and how it affects cognitive states of the brain. Further, the next studies should explore the use of neuroaesthetics to create more healing, enriching interior environments, particularly ICU environments. Healthcare environments are one of the few areas that are used by humans in very different bodily states, including injured patients, active employees, and stagnant patient family and friends. Research can explore all types of users in the ICU environment and how the same space effects different people in different emotional and physical states differently. Future research exploring symbolic functions in interior design can be explored through wayfinding, signage, or color associations. Other specific associations can be used within all interior design using the neuro-interior response theory to encourage healthier interior environments that can be directly associated with brain functions. Along with these suggestions, many more opportunities are available to researchers in the very beginning of this field of study.

Conclusion

The present study set out to explore the neural response to the ICU interior environment. Initial research revealed that the connection between neuroaesthetics and the ICU environment is an area of research that has yet to be explored (to the knowledge of this study). A content analysis explored neuroscience research studying architecture and interior design and may have revealed relationships between neuroscience, neuroaesthetics, and interior design. Results ended with a proposed theory, the neuro-interior response theory. Neuro-interior response theory suggests a connection between neural responses within the brain and interior environments. This theory aims suggests precedence for future research into neuroaesthetics and interior design.

Research questions for this study set out to find a phenomenon between neuroaesthetic response and the ICU environment, to explore the research regarding neuroaesthetics and the ICU environment, and whether assumptions can be made from research in neuroaesthetics and the ICU environment. Relationships suggested from the content analysis were used to explore the assumptions to be made from the research questions. First, research related to neural response and the ICU was not found within the extent of this study, but twelve neuroscience studies that focused on architecture and interiors may have found to be relevant to this topic. A phenomenon was then observed between neuroaesthetics and interior design, which may correlate to the ICU environment. Finally, assumptions were made that there is a suggested phenomenon between neuroaesthetics and interior design. The biggest assumption to be made in this study, though, is that all interiors response could relate to any type of interior space. None of the assumed connections established from this study resulted in answers in the research questions, but all three research questions could be explored further in future research on neural response to interiors. The lack of answers provided from the research opens many opportunities for the future of neuroaesthetic, interior design, neuro-interior response theory research. It is the goal of the study that the neuro-interior response theory can open up an entire genre of research in interior design that can inspire the future of interior design and how society experience interior environments.

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APPENDIX I

DATA ORGANIZATION

Table 4. ***Completed Data Organization Chart***.

Data	Open Coding	Axial Coding	Selective Coding
Amorapanth, et al. (2010).	*-Spatial Relations -Neural Processing -Physical Orientation*	-Neuroscience -Patient	**Neuroaesthetics in Healthcare Interior Design**
Bower, et al. (2019).	*-Healthcare -Interior Environment -Spatial Relations -Neural Processing -Neuroaesthetics -Emotion -Physical Orientation -State of Mind*	-Interiors/ID -Neuroscience -Patient	
Bromberger, et al. (2011).	*-Aesthetics -Neuroaesthetics*	-Neuroscience	
Coburn, et al. (2020).	*-Aesthetics -Interior Environment -Spatial Relations -Neural Processing -Neuroaesthetics*	-Interiors/ID -Neuroscience	
Eberhard, J. P. (2009).	*-Aesthetics -Interior Environment -Spatial Relations -Neural Processing -Neural Transaction -Neuroaesthetics -Patient Satisfaction*	-Interiors/ID -Neuroscience -Patient	

	-Physical Orientation		
Mirkia, et al. (2012).	*-Aesthetics -Interior Environment -Neural Processing -Neural Transaction*	-Interiors/ID -Neuroscience	
Nanda, et al. (2009).	*-Aesthetics -Healthcare -Interior Environment -Spatial Relations -Neural Processing -Neural Transaction -Neuroaesthetics -Emotion -Physical Orientation*	-Interiors/ID -Neuroscience -Patient	
Pati, et al. (2016).	*-Healthcare -Interior Environment -Spatial Relations -Neural Processing -Neural Transaction -Emotion -Physical Orientation*	-Interiors/ID -Neuroscience -Patient	
Pearce, et al. (2016).	*-Aesthetics -Neuroaesthetics*	-Neuroscience	
Salingaros, et al. (2008).	*-Interior Environment -Spatial Relations -Neural Processing -Neural Transaction -Neuroaesthetics*	-Interiors/ID -Neuroscience	

Spee, et al. (2018).	*-Neural Processing* *-Neuroaesthetics*	-Neuroscience	
Vink, et al. (2016).	*-Interior Environment* *-Spatial Relations* *-Neural Processing* *-Time Response*	-Interiors/ID -Neuroscience	