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Design Implications and Effects of Environmental Stressors in a Healing Space

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***Abstract*: Architecture has the unique ability of being able to have a direct effect on the way people feel within a space. This idea is never more evident than in the design of healing spaces. Healing spaces are charged with housing humans in some of our most physically and emotionally sensitive states. In this paper the author surveys the existing research on those elements of the built and natural environment most often asserted by proponents as being in inherently healing or promoting health. The research covers the neurological and behavioural implications of the outlined architectural elements on stress and anxiety reduction. Opportunities exist to make meaningful contributions in this area that are likely to make significant impact on health outcomes of human beings.**

***Keyword:* Healing spaces, physically, emotionally, neurological, behavioural.**

1. INTRODUCTION

Since the beginning of humankind, it is likely that people have been seeking safe shelter in which to heal. When little could be done to treat the physical causes of illness or injury, a safe, supportive environment where natural or supernatural forces could aid the recuperative process to help the patient heal was vital. Now we can design, build, and adapt healing spaces and measure their restorative effects.

The interaction between humans and the different environments in which they are placed has long been known .More than 2000 years ago, the ancient Roman physician Galen recognized the healing aspect that an environment could provide .He understood the consequences of unclean conditions; thanks to his health philosophy, he had the highest survival rate among all physicians who treated the gladiators (Pearcy, 1985). Florence Nightingale was also famed for her focus on sanitation and other aspects of the environment that contribute to the health and healing of the patients. She was not only a leader in improving sanitation and ventilation, but was also instrumental in bringing forth the body-and-mind connection [1]. She understood that the environment played a central role in a patient's healing of body and mind. Nightingale went on to influence the healthcare environment by varying the patient's visual perspective, utilizing colour and natural light more effectively, and eliminating excessive noise. This early nursing leader was passionate about the nurse's role to create a milieu that would give a patient the best opportunity to heal.

The utilitarian designs of the past created an ambience that dehumanized the patient's experience. Recent studies have supported Nightingale's practices from a century ago; the environment plays a significant role in the overall healthcare experience and healing process .Historically patients were placed in an open ward in beds that lined the walls. This design allowed for many patients to receive nursing care from a minimal number of nursing staff. Lack of privacy and exposure to repulsive sights and odours were some of the detractors of this type of design (Fontaine, Briggs, & Pope-Smith, 2001).

Even today ,with the many advancements that have been attained in neuron-architecture and evolution of evidence based theories, the same issues considered by Nightingale of air quality, colour, light, view, and noise are still of concern.

Stichler (2001), in her review of related research, reports that people experience positive afflictions when the environment incorporates natural light, elements of nature, peaceful colours, soothing sounds, pleasant views, and an overall pleasing aesthetic essence.

2. METHODOLOGY

- In the first part of the paper we will find the relation between various natural and built environment factors that help in healing.
- Through literature study of numerous neuro-scientific evidences we intend to find their implication on healing.
- In the second part I have documented the existing theories on design of healing spaces.
- The environmental factors that are perceived by human senses are studied at depth to understand their characteristics and access them qualitatively and quantitatively with respect to their impact on healing.
- In the final part of the paper I have presented some literature case studies of healing environments in hospital settings.
- In the last part of the paper design implications are extracted from the following neurological evidences and clinical trials.

3. BACKGROUND

HEALING ENVIRONMENT:

The physical environment, while being a dimension of healing in its own right, is intertwined with all other dimensions of an optimal healing environment. Some elements of environmental design may, in themselves, help or hinder healing.(Schweitzer, 2004).
This research paper tries to find out the architectural elements that contribute to development of healing spaces and subsequently finds out their neurological and behavioural effects.[2]

NEURO –ARCHITECTURE:

Earlier it was believed that our brain stops developing new neurons when we are early in our twenties. In 1998, Fred H. Gage (Salk Institute for Biological Studies) and Peter Eriksson (Sahlgrenska University Hospital) discovered and announced that the human brain produces new nerve cells in adulthood. Our brain is formed in the 3rd month of pregnancy, and after that grows remodelled by environments we are surrounded with. Neuroscience explains the connection between environment and behaviours; from perception to impulse transportation and how neurons built up and store information in our brains.[3]

When we learn all we 'think' and 'feel' are formed by our brain and nervous system, we realize the importance of our unique perception and impact of environments. In order to understand the relation between neuroscience and architecture, we can start with our basic activities that we use our five senses to perceive the environments. Perception also involves with our navigation in space, and neuroscience explains on how physical environment affects our cognition, problem solving ability and moods. Understanding these principles can guide architects to design built environment serving better spatial orientation, reinforcing cognitive abilities and minimizing negative effect in emotions and motivation.[4]

Neuro-architecture can be defined as built environment designed with principles of neuroscience, which establishes spaces that encourage memory, improve cognitive abilities, avoid stress and/or stimulate brain.

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CONTEMPORARY ARCHITECTURE AND STRESS:

Our mental processes enable us to interact with and adapt to our environment. We instinctively crave physical and biological connection to the world. The human perceptual mechanisms through which these processes work establish our relationship and response to both architecture and the built environment. The basis for this interaction is human nature itself: the end result of the evolution of our neural system in response to external stimuli such as the informational fields present in the natural environment Humans, seeking shelter from the elements, are compelled to construct buildings and cities. Historically, the form of those structures arose from within the material logic of their immediate surroundings, and from the spatial ordering processes of their minds (through biological necessity). Utilizing what was at hand to give

structure to existence, People instinctively constructed places that provided the constituent information, form, and meaning that their sense of wellbeing required. Design decisions occurred as a natural extension of the neurological processes that make us alive and human.

Not consciously aware of the nature of these processes, humankind simply built its buildings and cities in this manner without question for millennia. Over the course of time, however, the relationship to the physical world began to take on a greater complexity through applied meaning: i.e. local mythology, symbolisms, and social structures. As the process-of-building was usurped by the process-of-design, architecture as a tectonic expression of innate human ideas about form, space, and surface became more difficult to grasp. People's relationship to the physical world was further complicated with 20th-Century advances in technology and industrialization.

Numerous studies have determined that leisure activities in natural settings or exposure to natural features have important stress reduction or restoration effects (e.g., Parsons et al., 1998; Sheets and Manzer,1991; Ulrich, 1981). A frequently cited study is that by Ulrich (1984) who examined the effect of window view on recovery rate from gall bladder surgery. Two groups of patients were matched on age, sex, weight, tobacco use, and previous hospitalization. The pairs of patients thus differed only on their hospital room window view. One member of each pair looked out onto a group of deciduous trees whilst then other's window view comprised only a brown brick wall. The study results showed that those patients with the natural view recovered faster than those in the other group (i.e. their post-operative hospital stays were shorter). Also, the natural view group patients had fewer negative comments in the nurses' notes and they had fewer injections of potent pain killers compared to those with the wall view. Additional support for the restorative and therapeutic effects of nature has come from a large number of studies which have evaluated encounters with wilderness settings. These studies have typically evaluated already existing wilderness programs oriented towards special client groups such as psychiatric patients, abused women or adolescents. However, many of these studies have been criticized as being methodologically flawed, non-theoretical and for implementing poor research designs. In many, the subjects have been self-selecting and few have included comparison or control groups. In addition, determining the specific role of nature in such effects has been problematic since other elements of the activities, such as physical exercise, could be contributing (Hartig, Mang, and Evans, 1991). Despite these limitations, across many varied study designs and measures, there has been overall consistency in outcomes (Kaplan and Talbot, 1983).

In an another research it was found that the characteristics and quality of housing directly affect people's physical and mental health. A home that is cold and damp or has allergens may cause respiratory illnesses and asthma in the residents (Shaw, 2004; Wigle, 2003). The height and size of housing also has health effects on residents—high-rise housing is associated with psychological stress, particularly among low-income mothers of young children (Evans, et al., 2003). Children who lived in 14-story public housing were found to have greater behavioural problems than children living in three-story public housing (Saegert, 1982). Social isolation may be one reason for this, because parents are less likely to let their kids play outside if they live high up in a large building (Kim, 1997). And, finally, crowding has detrimental effects on both mental and physical health (Evans, 2001).

PSYCHOLOGICAL AND PHYSIOLOGICAL CONNECTION OF THE HEALING PHENOMENON:

Psycho euro immunology refers to the physiologic response of the body to psychological and environmental stressors (Starkweather,Witek-Janusek,& Mathews, 2005). This stress response is initiated by the hypothalamus releasing corticotrophin releasing factor (CRF). The CRF stimulates the pituitary gland to release a number of stress hormones, such as adrenocorticotropic hormone (ACTH). This hormone, in turn, stimulates the release of cortisol from the adrenal cortex and the release of aldosterone from the adrenal medulla. Cortisol, a glucocorticoid, stimulates the release of glucose from glycogen in the liver.

Aldosterone, a mineralocorticoid, acts to retain sodium and water. Both of these hormones cause an increased blood pressure in the ICU patient (Lusk & Lash, 2005). Furthermore, cortisol depresses phagocytosis, which can affect healing.

Psychoneuroimmunology research demonstrates that emotions influence immunological functioning and that too much stress has a negative impact on the functioning of the body's immune system. Recent research suggests that the immune system can be enhanced or suppressed by external stimuli and that the brain reacts to external stimuli at an unconscious level (Malkin, 2003). The physiological effects of stress negatively affect patients' ability to heal. Information received through our five senses evokes physiological and emotional responses of anxiety or serenity (Mazer, 2002).

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4. EXISTING THEORIES ON CREATING HEALING SPACES

ULRICH'S THEORY OF RESTORATIVE DESIGN:

Dr. Roger Ulrich's theory of restorative garden design is based on theory and research in the behavioural sciences and health-related fields. His theory proposes that gardens in healthcare situations are important stress mitigating resources for patients and staff because they foster:

(i) Social support

(ii) Sense of control

(iii) Physical movement and exercise

(iv) Access to nature and other positive distractions (Ulrich, 1999).

Figure 1: Ulrich's theory

Research-based evidence exists to show that each of the four restorative components mentioned above can reduce stress and thereby improve other health outcomes. It must be noted that gardens at healthcare facilities serve a wider population group than the patients / residents. Families and visitors, as well as staff, are also important users of these outdoor spaces. An engaging garden can provide a venue for activity, topics of conversation, and memory cues for both visitors and patients. These garden features can enhance the quality of the visit, which in turn enhances health outcomes for the patient and brings visitors back more frequently. Staff are another important user group for outdoor spaces at healthcare facilities.Staff often have stressful jobs and frequently have no place to go for a break.Garden spaces can provide a sorely needed escape from the pressures of the job.

THE BIOPHILIA HYPOTHESIS:

In his 1984 book entitled Basophilic, Wilson described his biophilia hypothesis as a human "innate tendency to focus on life and lifelike processes."(p. 1). Indications of the human tendency to maintain contact with nature can be seen throughout history. The homes of the ancient Egyptian nobility, Persian settlements, and medieval Chinese villages were all marked by extensive and elaborate gardens demonstrating that people went to considerable lengths to maintain contact with nature (Ulrich, 1993). In more recent times, particularly the last two centuries ,the provision of parks and the preservation of nature reserves have been supported by the belief that exposure to nature fosters psychological well-being, reduces the stress related with modern living and promotes physical well-being (Ulrich, 1993).[5]. Not only are these places provided, they are extensively frequented. Indeed, people crowd national parks to experience natural landscapes. They travel long distances to stroll along the seashore, and the wealthy select dwellings on prominences above water or amidst parkland. Humans' affiliation with nature is also reflected in their expressed enjoyment in making contact with or

viewing other species. For example, in the United States and Canada, more children and adults visit zoos than attend major professional sporting events combined (Wilson, 1992; 1993). In America alone, there are 40 million pet cats and 55 million pet dogs (Newby, 1999; Shepard, 1993).

The significance of biophilia has profound implications. According to this hypothesis, given our species' long history as subsistence hunters, gatherers, and farmers, it is inconceivable that the natural environment has not shaped our cognitive and emotional apparatus. Our tendency to affiliate with nature in all likelihood enhanced the fitness of our ancestors. The brain which modern members of our species have inherited must be a product of this evolutionary process – a brain attuned to extracting, processing, and evaluating information from the natural environment (Wilson, 1984; 1993).[6]

According to the biophilia hypothesis, when humans become removed from the natural environment, the biophilic learning rules do not become replaced by modern versions. "Instead, they persist from generation to generation, atrophied and fitfully manifested in the artificial new environments into which technology has catapulted humanity."(Wilson, 1993; p. 32).

In short, the brain evolved in a bio-centric world, not a machine regulated world. It would be therefore quite extraordinary to find that all learning rules related to that world have been erased in a few thousand years, even in the tiny minority of peoples who have existed for more than one or two generations in wholly urban environments(Wilson, 1993; p. 32).

5. HUMAN SENSES AND ENVIRONMENT

To explore the various architectural elements that affect the healing process in a space we have to classified the elements on the basis of how they are perceived .Humans perception is governed by the internal and external senses that are ; Sight ,hearing ,smell ,taste and touch there are also other internal senses such as ; Thermoception and proprioception .These senses help us to perceive a multitude of elements.

The recent advancements in neurological science coupled with evidence based designs and behavioural science literature can help us to determine the qualitative and quantitative attributes of the elements we perceive in the built environment and nature that would aid in stress recovery and subsequent neurological nourishment.

These outlined environmental factors have the biggest role in creating stress relieving spaces because these factors have a dual nature .These factors are studied because primarily these are the most essential factors that are present in any environment and also these factors can be suitably modelled by the Architect for developing proper effects of stress relief Secondly these elements not only provide stress relief but if used without proper knowledge about design of healing spaces these very factors become environment stressors .Thus these elements have to be thoroughly studied and understood for designing a healing space.

Sense	Elements perceived
Sight	Color ,light, forms, texture and patterns
Smell	Odour
Hearing	Sound
Taste	---
Touch	Textures and forms
Thermoception	Temperature
Proprioception	Relative positioning and efforts in movement

VISION:

Vision is one of the most important senses and is also responsible for perception of light, colour ,patterns ,forms and texture in the space. A space that is visually beautiful, with the right kind of lighting, colour and use of materials to bring in textures, patterns and forms, creates a largely positive ambiance. Explained below are the effects of colour, light

architectural elements on the human mind. Texture and forms is dealt with in a different section because it goes beyond just the visual aspect of the space.

(5.1) Light:

Light serves for various purposes: to make spaces to find the orientation, to reveal or conceal the spatial volume or features, or to draw attention to a task. Our perception and desire for light also varies among the purposes we will need the light for, for example Spaces for meditation or relaxation have different light requirement than that of space for physical activities.

When performing a visual task, the light that reaches our eyes and is therefore laden with the raw information for our mind is usually reflected light.

Daylight may serve a vast spectrum of users without any major problems but Direct day lighting may cause certain discomfort. The Daylight produces glare and direct incidence can also heat up the environment and may reduce the usability of the space. The space in the outdoor environment like meditation rooms or learning rooms may be designed within an envelope of with low transmitting glasses, or shadings, also general outdoor spaces should be designed such that the direct incidence of western and south western lights can be avoided with shading from natural elements.[7]

(5.1a) Lighting as an Environmental Stressor:

Of particular interest is evidence that stress levels are responsive to light conditions. The association between stress, cardiac, and healing (immune and inflammatory) responses is now well documented (Sternberg, 2003).Many studies show that stress responses change rhythmically with diurnal modulation, and yet our built environments provide constant, non-cycled light settings. The relationship between light and stress relief outcomes is most important in outdoor environments.

(5.1b) Circadian Lighting:

Based on some of the evidence cited above, it has been suggested that the introduction of brief "light showers" might provide a means to modulate circadian responses (Figuero et al., 2006). Such solutions will be particularly useful in built environments where the climate or architectural configuration limits access to adequate natural circadian lighting (e.g., compass orientation, interior spaces, etc.). A number of studies conducted in real world situations show that brief exposure to individual lighting devices can assist in modulating sleep patterns and behaviour (Ancoli-Israel et al., 2003).

(5.1c) Exterior Conditions:

Scientific data reveals that the built exposure to exterior conditions or climates may not provide enough light for circadian stimulation, or may provide more light than is needed to drive circadian rhythms. If an external site does not provide sufficient natural light,window design alone cannot be used to specify the amount of light that will enter a space.

(5.1d) The Circadian Cycle:

Every species on earth exhibits a wide range of biological cycles that repeat approximately every 24 hours .These are known as circadian rhythms (circa –approximately ,dies-day) and are exhibited at every level of biological systems, from timing of DNA repair in individual cells to behavioural changes ,like the sleep-wake cycle. Considering the significance of the light-dark cycle for regulating biological functions, and the accumulation of evidence from epidemiological and animal studies linking circadian disruption to compromised health and well-being

Circadian Responses:

While there is a significant body of evidence that demonstrates that electrical light sources can be used to drive many circadian responses, it cannot be said that a single electrical light condition can replace solar light as a means to stimulate all circadian effects. Many human systems respond to circadian and seasonal lighting changes. Only a few aspects are well understood, and more research is clearly required. Nonetheless, we can form some general design hypotheses based on current findings that are expressed below.

Analytical Approach:

A published model of human circadian photo-transduction (i.e, the conversion of optical radiation incident on the retina to neural signals) was used to estimate levels of circadian stimulation from four typical outdoor light sources as might be

experienced by people under different realistic scenarios. The approach taken was to determine whether sufficient light is incident on the retina to reach a working threshold for stimulating the circadian system and, thereby to ascertain whether and to what degree outdoor lighting might stimulate the circadian system, as measured by melatonin suppression.[8]

Results:

A 6900 K LED is predicted to have a modest stimulating effect after a one hour exposure (corresponding to 12-15% Nocturnal melatonin suppression).A reasonable and conservative working threshold for suppressing nocturnal melatonin by light at night following a 30-minute exposure would be about 30 lx at the eye for a "white" light source.It is expected that human function, performance, biological, medical, and mood responses will change subject to lighting conditions.

Benefits:

It is expected that human function, performance, biological, medical, and mood responses will change subject to lighting conditions. This is not to say that the simple response of creating more light or more windows will suffice. Architectural and electrical lighting must be designed for users, their function, and their environment over time.

(5.2) Colour:

Perceived colour is based on the relative activity of ganglion cells whose receptive field centres receive input from red, green, and blue cones. It appears that the ganglion cells provide a stream of information to the brain that is involved in the spatial comparison of three opposing processes: light versus dark, red versus green, and blue versus yellow (Bear, Connors, &Paradiso, 2001).Since perception of colours differ from age to age and between mental states, for enriched environments it will be a more common approach to determine the colours by their brightness colours instead of grouping them with their perceptions. When colours are brighter they will behave as stimuli since they are more recognizable. Brains remember the things easily that are more remarkable. If the colours are used in connection with the spaces, it can strengthen the position in the mental map, and stimulates the memory. However same stimuli are not desired for every function. The brighter the colours , the more attention they attract. It will a better solution to involve neutral colours, with less contrast, and preferably light colours to perform with lighting.[9]

Colour preference has been studied for several decades and across many cultures. The following reviews a small subset of this work in order to demonstrate the complexity that must be accounted for in designing colour experiments, and for the interpretation of the results.

(5.2 a) Cultural Effects:

Abel's study (2005) of 90 undergraduate students from 5 different cultures expressed colour preference in mosaic design. Researchers found that Japanese students preferred green and Mexicans blue, and that Iranian students chose fewer colours. Choungourian(1968) found definite cultural and some gender differences in colour preference of paired comparisons among 160 American, Iranian, and Kuwaiti university males and females.Saito (1996) studied 490 university students (Japanese, Chinese, Indonesian), who selected the most liked colour from a colour chart. People from each country showed tendencies for unique colour preferences, with significant differences in frequency of colours and hues .Our Study of 100 undergraduate students of architecture discipline selected most of royal blues and green colours. A high preference for white was common, along with a preference for some colours. Images based on environmental and cultural aspects may be important influences. However, in order to make direct cultural comparisons, one must also consider the influence of changing preferences that occur over time, and that such changes differ across country and culture even within the same location. A rigorous analysis is required for comparisons across references in order to discern rigid or fixed preferences that will stand the test of time and location.

(5.2 b) Performance and Mood:

Kwallek et al. (1996) studied the effects of 9 monochromatic office interior colours on clerical tasks and worker mood. Pre/post studies of 9 treatment groups examined proof reading performance, 6 mood states, and colour preference in high/low saturation, dark/light value, and warm /cool colours, in 341 male and 334 female subjects (16–37years). Significantly more errors were made in the white room than in blue and red, with females performing significantly better than males. Saturation of colour was the most salient predictor of difference between male and females, with females indicating more depression, confusion, and anger in low saturation colours (white, gray, beige), and males in high saturation colours (green, blue, purple, red, yellow, and orange). Subjects revealed that they would prefer to work in beige

and white offices over orange and purple offices. Ishihar (1995) found that 50 male prisoners with normal colour vision responded similarly to normal subjects. Colour preference was assessed using the colour pyramid test in normal subjects (green, blue, red, and yellow in descending order). Kuznetsov et al. (1990) used colour selection from the LCT as an indication of emotional status in pilots post training.

Categorizing colour-emotion pairs, 14 British and 17 Chinese students assessed 20 colours and 10 colour-emotion scales. There were no significant differences between males and females, but three scales were identified: colour-activity, colour-weight, and colour-heat. Physiological Influence on Colour Perception and Preference: Of course, in considering the physiologic bases affecting colour perception, one must control for different colour vision and deficiencies in individuals of different genders, age and health status (Buckalew et al., 1989; Levinthal, 1983). In particular, natural aging of the lens alters not only the optics, but also colour through which the environment is perceived (Hardy et al., 2005). Also, medical conditions beyond visual disorders have both expected and unexpected impact on colour perception and preference, such that deaf children tend to show greater preference for colour over form.(Serpell, 1979).

(5.3) Patterns:

Patterns recognized by our neurophysiologic apparatus are a key to understanding humanity and its connection to the universe. Patterns organize individual actions into more complex wholes. While this is a process well understood in a language, where words are combined to achieve a meaningful message, it remains outside most people's analytical understanding of the world. Cognitive psychologists recognize patterns as schemata that identify certain preferred sensory inputs. Patterns also control coordinated body movements. Almost every human activity will be found to contain patterns, and those patterns generate the forms and connective complexity of traditional architecture and urbanism (Alexander *et. al.*, 1977)

Whereas some design components are contextual (i.e. cultural, temporal, or location-specific), many are indeed universal. Christopher Alexander's *Pattern Language* codified evolved patterns of how humans interact with their environment and with each other (Alexander *et. al.*, 1977). This prescient book established a practical combinatoric framework for design, based on evolved solutions. Incidentally, it already contains many of the key concepts that later came together to define biophilic design. In Appendix II of this Chapter, we have summarized several Alexandrine patterns. The reader can readily see how these design patterns anticipate and support restorative or contemplative design.[10]Architects can draw upon the *Pattern Language* (Alexander *et. al.*, 1977), combining that helpful knowledge with the latest notions of human adaptivity into an innovative design

(5.4) Hearing

(5.4 a) Sound

Previous research in this area has mainly used visual stimuli, for example videos and photographs of nature settings and urban areas. However, sound stimulation is also known to be a potent stressor, evoking unpleasant feelings (annoyance) and physiological stress reactions, especially at high sound pressure levels. Studies on the connection between sound environment and stress recovery are currently lacking. Soundscape research has shown that natural sounds are typically perceived as pleasant and technological noise as unpleasant components of the sound environment. It is therefore plausible that the sound environment may have a similar effect on stress recovery as the visual environment.

Ulrich *et al*. used video films with sound and found faster physiological stress recovery during exposure to films depicting nature compared with urban environments. However, Ulrich *et al.* did not control for sound pressure level. Indeed, the soundtrack to their films of urban environmental settings had considerably higher sound pressure levels than the soundtrack to the films of nature environments. This makes it difficult to determine whether the effect was related to the characteristics of the environments or to differences in sound pressure levels. So, although positive effects of visual natural environments are well established, no research has been done using only auditory stimulation with controlled stimuli and sound pressure levels.[11]

In another study researchers induced psychological stress and compare effects of different sound conditions on the rate of physiological recovery. The sound conditions were chosen so that a pleasant natural sound environment was compared with three less pleasant urban sound environments dominated by noise. To study effects of sound pressure level on physiological recovery, the urban sound conditions had higher, equal, or lower average sound pressure levels than the nature sound. Two measures of physiological stress were used: SCL as an index of sympathetic activity and HF HRV as

an index of parasympathetic activity. Physiological recovery is associated with a decrease in sympathetic activation (*i.e.*, SCL decreases) and an increase in parasympathetic activation (*i.e.*, HF HRV increases). Because physiological stress recovery should be faster during exposure to pleasant than to unpleasant sounds, we hypothesized that (a) SCL should decrease faster and (b) HF HRV increase faster during pleasant nature sound than during less pleasant noise.

The main purpose of this study was to test whether physiological stress recovery is faster during exposure to pleasant nature sounds than to noise, results show that mean SCL during the nature sound was lower than for the noises. Although this difference was statistically significant only between the nature sound and the high noise, detailed analyses of the recovery functions showed that half-life SCL recovery was 9−37% faster during the nature sound than during the noises. These results suggest a faster recovery of the sympathetic nervous system during the nature sound. Because HF HRV showed no effects of experimental sounds, this null finding suggests that the parasympathetic activation may be less affected by sound during recovery.

The present results suggest that recovery from sympathetic arousal is affected by type of sound (nature sound *versus* noise). Recovery was faster during the nature sound (50 dBA) compared with the noises, including the low noise (50 dBA) and the ambient noise (40 dBA). The mechanisms behind the faster recovery could be related to positive emotions (pleasantness), evoked by the nature sound as suggested by previous research using non audio film stimuli. Other perceptual attributes may also influence recovery. The Ambient noise was perceived as less familiar than the other sounds , presumably because it contained no identifiable sources. One may speculate that this lack of information might have caused an increased mental activity and thereby an increased SCL, compared with the nature sound (cf. An effect of sound pressure level can be seen in the difference between high and low noise, this difference is in line with previous psychoacoustic research and is not a surprising considering the large difference (30 dBA) in sound pressure level.

The results from SCL are consistent with those of Ulrich *et al.* who found a faster decrease in SCL after audio-visual exposure to natural compared with urban environments.

The effect of natural sound environments on stress recovery may be greater in situations with longer exposure times and with lower sound pressure levels commonly found in recreational and rural areas outside cities. In city parks and other urban outdoor areas, the sound environment is typically a mix of sound from nature sounds and traffic noise. Based on the present results, it seems plausible to speculate that recovery from sympathetic activation in such areas would be less effective than in areas undisturbed by noise.

The present results suggest that after psychological stress, physiological recovery of sympathetic activation is faster during exposure to pleasant nature sounds than to less pleasant noise of lower, similar, or higher sound pressure level.

(5.5) Smell:

(5.5 a) Odour:

Smell is the primary element that immediately influences the human behaviour. We live in a culture that overwhelms us with stimulation delivered through sight and sound. Even taste and touch are highly valued and utilized to expand our experience of pleasure and sensuality (Luke Vorstermans, 2007). But a human's sense of smell has been relegated to the bottom of the sensory pile.

Unlike the other senses, the sense of smell is always on duty. Each day, without any thought, a person breathes in over 23,040 times, inhaling over 238 cubic feet of air (Luke Vorstermans, 2007). Each breath floods the smell receptors with information about the surrounding environment. We are capable of recognizing approximately 10,000 different odours, with each odour having the power to influence our moods and behaviour.

Smell has a powerful effect on behaviour. Certain smells can brighten up the moods and lift our spirits, like the smell of a good cup of coffee and warm cinnamon buns straight from the oven. An exotic perfume or the smell of your lover's skin can lead to intimacy and romance while other scents bring a sense of calm and make us feel at home (Luke Vorstermans, 2007).

Aromas delivered directly to the smell receptors in our brain have a powerful effect on our behaviour. (Luke Vorstermans, 2007).Since birth, the human smell receptors have been busy cataloguing every smell that passed through the nostrils.[12]

The brain processes information delivered through our other senses by cognitive identification first, which in turn triggers an emotional response (Luke Vorstermans, 2007). But the sense of smell is unique. It does the opposite. Our smell receptors are directly connected to the limbic system which controls emotional behaviour and memory. Incoming odours first trigger an emotional response which is then followed by cognitive recognition (Luke Vorstermans, 2007). This is the reason that the refreshing smell of lavender comforts us before we realize the presence of it around us.

Aromas have long been used to influence behaviour. "Legend has it that Cleopatra perfumed the sails of her ship sent to meet Anthony so the wind would carry a hint of her desire" (Luke Vorstermans, 2007). For centuries, doctors would diagnose various diseases by smell alone and we all know that our shopping experience is influenced by the smells funnelled through the air conditioning systems. Smells are being introduced everywhere – in our household products, our homes, our cars and office environments (Luke Vorstermans, 2007).

(5.6) Touch:

(5.6 a) Texture:

Texture is a subject of two senses – vision and touch. For instance, the decorative value of a wall paper or a wall colour largely depends on the texture used on it. The dead gloom of black and the dead glare of white are relived and endowed with life and animation, as the heat of red, the cold of blue and the brilliancy of yellow are tempered with texture (Ghosh, 2009).

Visual textures are produced by the patterns given to the lighting of the surface both through the way the materials are worked (*e.g.*, vertical or horizontal chiselling of stone) and through the way they are employed in building (*e.g.*, vertical or horizontal boarding, projection and recession of courses of brick). Like all patterns, visual textures create associations of movement, giving rhythm to the surface.

(5.7) Forms:

Human beings connect physiologically and psychologically to structures embodying organized complexity more strongly than to environments that are either too plain, or which present disorganized complexity (Salingaros, 2006). It follows that the built environment performs a crucial function — in some instances to the same degree — as does the natural environment. The connection process (outlined in the following sections) plays a key role in our lives, because it influences our health and mental well-being. Studying the geometrical characteristics of the type of visual complexity responsible for positive effects reveals its commonality with biological structures. Applying such concepts to architecture leads to two distinct conclusions. First, that we should bring as much of nature as we can into our everyday environments so as to experience it first hand; and second, that we need to shape our built environment to incorporate those same geometrical qualities found in nature.[13]

A second, and much deeper aspect of architecture for healing spaces requires us to incorporate the essential geometrical qualities of nature into the building and urban structure. This implies a more complex built geometry, following the same complexity as natural forms themselves. Once again, there is a danger of misunderstanding this geometry and superficially copying shapes that are irrelevant to a particular building or city.(Alexander,2002-2005; Salingaros, 2005; 2006).

Neurological nourishment depends upon an engagement with information and its organization. This connective mechanism acts on all geometrical levels, from the microscopic, through increasing physical scales up to the size of the city. The correct connective rules were rediscovered repeatedly by traditional societies, and are applied throughout historic and vernacular architectures. Traditional ornamentation, colour, articulated surfaces, and the shape of interior space helped to achieve informational connectivity. Long misinterpreted as a copy of natural forms, ornamentation in its deepest expressions is far more than that: it is a distillation of geometrical connective rules that trigger our neurophysiology directly. These qualities are emphatically not present in the dominant architectural ideology of the twentieth century. Some architects consider that neurological nourishment comes strictly from living biological forms. In their view, ornamented forms and surfaces are derivative of natural forms, and thus provide only a second-hand (i.e. vicarious) experience. We, on the other hand, believe that the underlying geometrical complexity of living structure is what nourishes humans. This geometry could be equally expressed in biological organisms as in artefacts and buildings: the difference is merely one of degree (Alexander, 2002-2005). If implemented correctly, it is not neurologically discernable, only more or less intense. Every living being incorporates this essential geometry to an astonishing degree (in

its physical form), whereas only the greatest of human creations even come close. In this view, the distinction between the living and the artificial is left intentionally vague, and life itself is drawn closer to geometry. At the same time, this approach helps to explain the intense connection people feel with certain inanimate objects, i.e. the artefacts and creations of our human past.

Traditional techniques for creating neurologically-nourishing structures are wedded to spiritual explanations, which are often unacceptable to contemporary architects (and to business clients). Not surprisingly, the most intense connection is achieved in historic sacred sites, buildings, and artefacts. It is only in recent times that a scientific explanation has been given for what were originally religious/mystical practices of architecture and design (Alexander, 2002-2005; Salingaros, 2006). Today, it is finally possible to build an intensely connective building and justify it scientifically, by extending the geometrical logic of the natural world into the built world.

To summarize, two branches of contemporary architecture are beginning to be practiced today (Kellert, 2005). One basically continues to use industrial typologies but incorporates plants and natural features in a nontrivial manner; while the other alters the building materials, surfaces, and geometry themselves so that they connect neurologically to the user. This second type ties in more deeply to older, traditional, sacred, and vernacular architectures. So far, the first (high-tech) method has an advantage over the second (mathematical/sacred) method, because it is already in line with the industrial building/economic engine of our global society. Visually and philosophically very distinct, nevertheless, these two movements are contributing to a rediscovery of our immediate connection to the environment.

Perhaps the greatest impact of the biophilic movement is to establish a value system for a particular group of essential geometric qualities. Living forms and the geometrical characteristics they embody must be protected from destruction, because they provide us with neurological nourishment (Wilson, 1984). This is the seed for conservation, both of biological species, as well as for historic and traditional architectures.

(5.8) Thermoception:

(5.8 a) Thermal Comfort:

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55). Maintaining this standard of thermal comfort for occupants of buildings or other enclosures is one of the important goals of HVAC design engineers.

Whenever the studies referenced tried to discuss the thermal conditions for different groups of occupants in one room, the studies ended up simply presenting comparisons of thermal comfort satisfaction based on the subjective studies.

Although different researches are undertaken on thermal comfort of people, it is also necessary to study the effects of thermal comfort conditions on the quality and the quantity of healing for patients in hospitals. There are also original researches that show the link between thermal comfort for staff and their levels of productivity, but no studies have been produced individually in healing spaces in this field. Therefore, researches for coverage and methods individually for this subject are recommended.

Finally, the interaction between people, systems and architectural design in healing spaces is a field in which require further work needed to improve the knowledge of how to design buildings and systems to reconcile many conflicting factors for the people using these environments.

(5.8 b) Proprioception:

The ability to sense stimuli arising within the body regarding position, motion, and equilibrium. Even if a person is blindfolded, he or she knows through proprioception if an arm is above the head or hanging by the side of the body. The sense of proprioception is disturbed in many neurological disorders. It can sometimes be improved through the use of sensory integration therapy, a type of specialized occupational therapy.

Today, it is believed that proprioception refers to 2 kinds of sensations: that of static limb position and of kinesthesia. Static position reflects the conscious recognition of the orientation of the different body parts, while kinesthesia is the conscious recognition of rates of movement. In general, impulses from receptors in the joints and surrounding tissues are synthesized into a picture of the body's position. The brain then functions to perceive this information. Unfortunately, however, the system for proprioception is not quite that simple. Rather, proprioception is based on a multi-component

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sensory system which includes: various types of peripheral receptors which detect specific signals and major sensory afferent pathways which carry the information from the spinal cord up to the cortex. (Johnson et al. 2008)

6. LITERATURE CASE STUDY

Salem VA Medical centre:

The SVAMC intends to take the patients' interactions with nature even further through implementation of a large healing garden on their campus. The healing garden encompasses about 1 ¾ acres, and will contain areas for a variety of activities. A number of treatment programs will use the garden for their patients.[15]

SVAMC Healing Garden Concept:

Originally, the SVAMC was planning to implement a wander garden at the facility, but the idea evolved into something bigger. Attention turned towards creating a large-scale healing garden that more patients at the facility could benefit from, while still including a dementia garden area in the design.

Healing Garden Areas and Uses:

One of the predominant goals for the SVAMC healing garden is to keep things as natural as possible. Through the early design process it was determined that the garden should incorporate both passive and active areas. The passive areas will be conducive to meditating, and will include more tranquil, therapeutic gardens. The active spaces will require a higher degree of programming and incorporate areas for more traditional horticultural therapy activities.

The programs that will be using the garden are: Dementia and Alzheimer's, Vocational Rehabilitation, Physical Therapy, Music Therapy, Neurocognitive Rehabilitation, and PTSD.

SVAMC Healing Garden concept plan. For the purpose of this report the garden is divided into separate sections as a reference to specific areas that will be discussed further. (Plan courtesy of the Salem VA Medical Center)

A – Passive Garden Areas

B – Alzheimer's Garden

C – Horticultural Therapy Areas and Conservatory

D – Physical Therapy Garden

E - Labyrinth

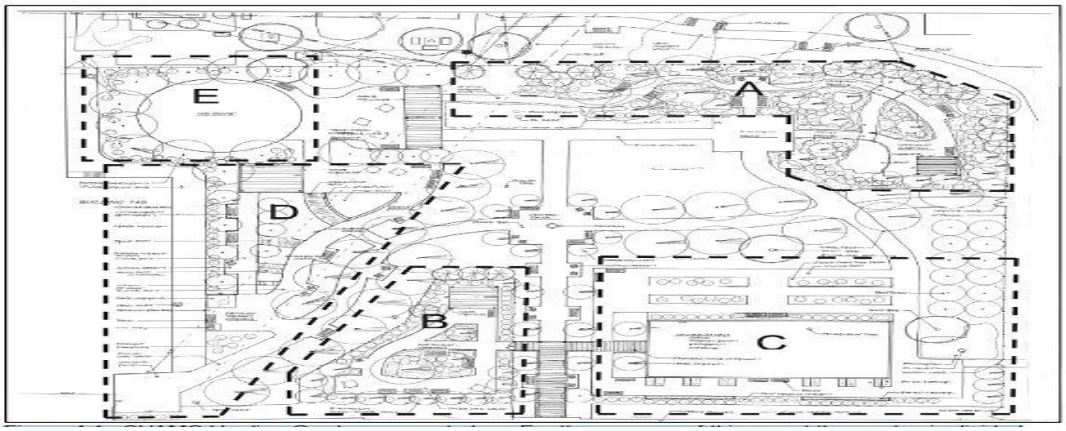

Figure 2: Healing Garden

The passive garden areas (see Figure 3) features meandering paths lined with planted spaces. Benches and seating areas will be spread throughout to provide areas for meditation, contemplation, and group sessions. Shade structures are also located at various points in the garden which will give relief from the sun to veterans and visitors to the garden .Water

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features like meandering streams and fountains will provide tranquil sounds in the garden, and strengthen the connection to nature.

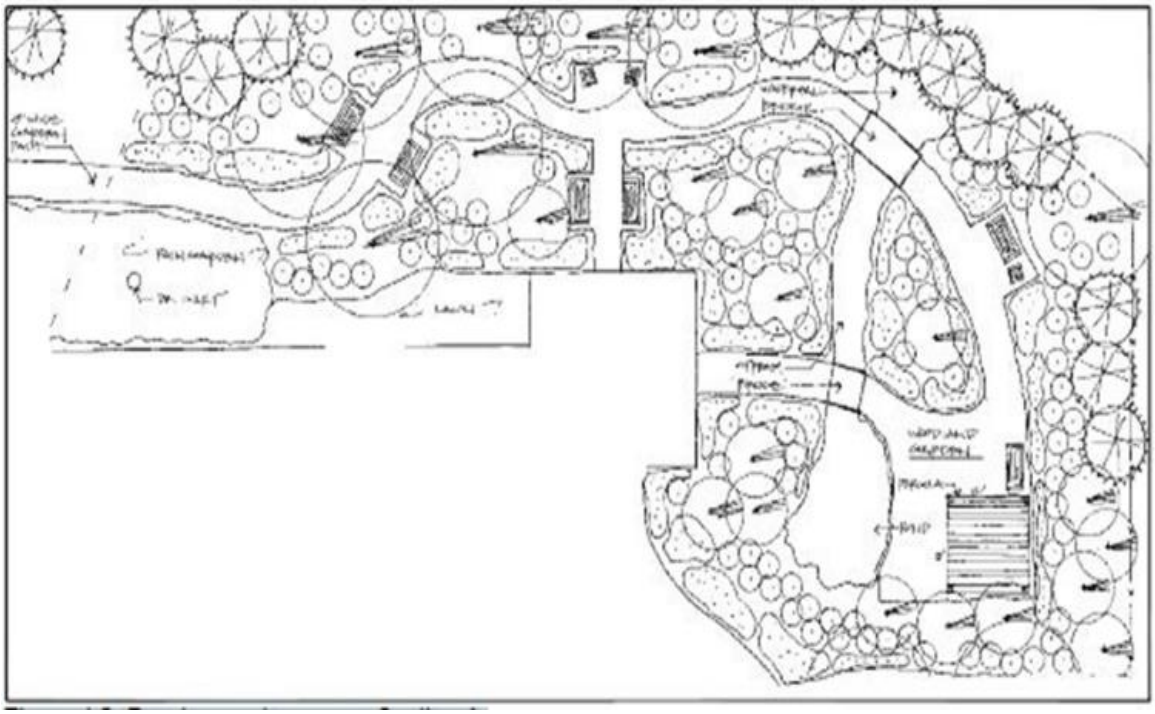

Figure 3: Passive Area

The Alzheimer's Garden (see Figure 4) is another passive area. Veterans with dementia and Alzheimer's can sit and safely enjoy the outdoors in this space. The Woodland Garden, described later, will also provide a tranquil, meditative space. Plantings in this area will mimic more of a rural, natural landscape. It will be planted heavily with evergreens, shrubs, and perennials that can figuratively take veterans out of the facility into "the great outdoors". A waterfall and stream enhance the space and provide soothing sounds.

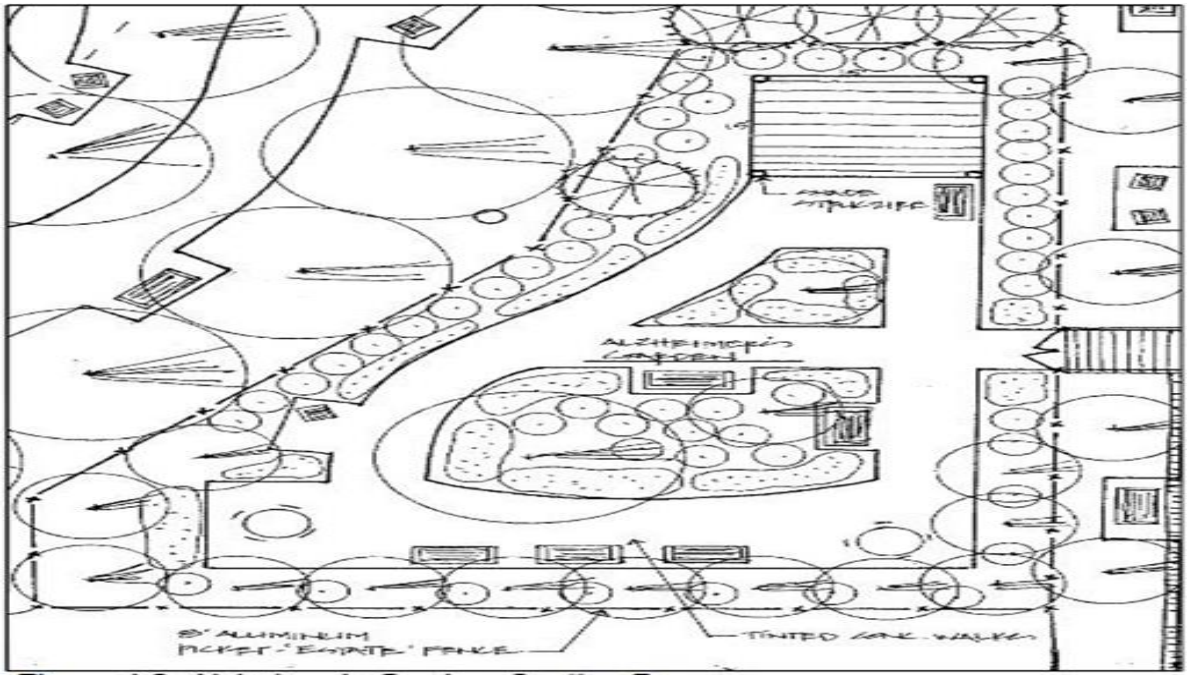

Figure 4: Alzheimer's Area

The Physical Therapy garden (see Figure 5) will be largely utilized by physical therapy patients. Exercise stations and rehabilitation elements such as handrails and a variety of walking surfaces will be incorporated there.

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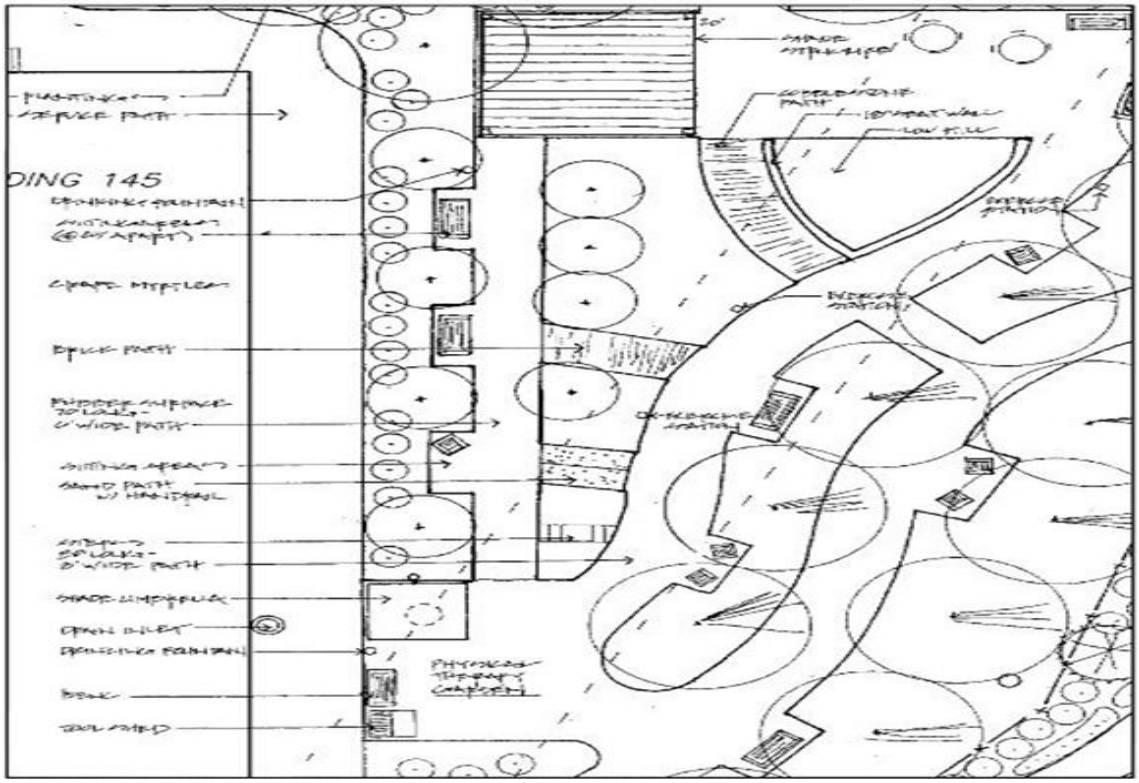

Figure 5: Physical Therapy Garden

7. ANALYSIS

Through the study of the various environmental stressors ,their neurological implications and with the help of the case studies, I have outlined the optimal conditions for these factors and also found out the suitable design elements or attributes that can help create a restorative space.

Perceived elements	Optimal conditions for a restorative space	Architectural Implications- Design elements and attributes
Light	Males' mood is best around 3000K, whereas females' is best around 4000K. During a night a 6900 K LED is predicted to have a modest stimulating effect after a one hour exposure (corresponding to 12-15% Nocturnal melatonin suppression).	**Building footprint and the perimeter to interior ratio** • Thinner building footprints, or an increased perimeter to interior ratio that Enable solar light to penetrate deeper into the building interior. **Windows and architectural openings** • Architectural openings and windows as required by code and guidelines • Climatic and site conditions, building orientation and built adjacencies, window design, and interior obstructions, materials and finishes determine the intensity and spectrum of light entering the building and reaching the level of the eye. **Access to exterior spaces** • Accessible paths and views to exterior spaces with direct, reflected, or shaded solar access . **Electrical lighting** • Electrical lighting with automated controllers • Multiple lighting solutions should be used to reflect the geometries and materials • Procedural lighting, visual acuity lighting, healthy lighting for circadian function, therapeutic lighting, and lighting for

		communication and amenity all have different optimal lighting ranges. **Circadian lighting** • Field studies of actual light levels reveal that use of sun shades and adjacent electrical lighting have a great influence on the amount of light the people receive. • Work areas should be provided circadian lighting as well as views. In those areas where procedures require dim lighting, priority should be given to nearby respite or work areas that provide adequate circadian lighting conditions.
Colour	Studies have shown that using calming colours can promote rest in critical care units .Blues, greens, and violet are appropriate, because they have healing and calming influences and are stress-reducing colours. Reds, orange, and yellow colours should be avoided, because they induce excitement, increase blood pressure, and can cause fatigue.	1.Visual acuity improves when the surrounding light is of a high colour temperature (blueish rather than red-ish). If the colour temperature of the ambient lighting is changed from low (incandescent) to high (a cool fluorescent), it is possible to achieve the same level of visual clarity while using a quarter of the light and electric power. 2.Control of brightness ratios, maintaining a difference of 3:1 between the surfaces of a book and the desktop, or 5:1 between the book and a surrounding partition, 10:1 between the book and a distant wall, and 20:1 between the book and a bright window, will reduce eyestrain and stress. Human Response to Colour **Colour ,Common Association and Nature Symbol** Red- High energy, passion, excitement Earth raised blood pressure Orange- Emotional expression, warmth Sunset Yellow -Optimism, clarity, intellect, Sun mood enhancement, excitement, aging Green- Healing, nurturing, unconditional Growth love Blue -Relaxation, serenity, loyalty, Sky and ocean calming, healing Indigo -Meditation, spirituality Sunset Violet -Spirituality, stress reducer, Violet flower feeling of inner calmness
Sound	Stress recovery is faster during the nature sound (50 dBA) compared with the noises, including the low noise (50 dBA) and the ambient noise (40 dBA).This has been proven in a scientific experiment conducted by Ulrich.	Indoor 1. Sound proofing of the building block with the use of acoustic panels etc. 2. Design of the building should be such that it supports sound masking in the interior of the building. Outdoors **1. Sound Absorption-**This method uses plants to entrap or absorb sound vibrations. Sound is absorbed by all parts of the plant such as leaves, branches, twigs and wood. The rougher the bark the better it absorbs sound. Experts say the best species for this will have many branches and thick, fleshy leaves with thin petioles (leaf stem). These broadleaf species lose their effectiveness in the winter when deciduous. **2. Sound Deflection and Reflection-**This method causes the noise to be bounced away from the recipient and sometimes back toward the source. The difference is based upon the density and rigidity of the barrier. Your designer can create attractive and effective partitions that may serve as a fence, but also double as sound barriers . **3. Sound Refraction-**This little known effect occurs when noise is dissipated, diffused or dispersed by striking a rough surface on any plain. It's easier to understand using a room of your house as an example. If it is empty with a bare floor and walls, every sound bounces off the hard surfaces to magnify it or even cause a slight

		echo as it bounces around. Add carpeting and the echo vanishes. **4. White Noise**-This is a very different solution than the first three. It is designed to create sound that is appealing to the human brain as a mask for undesirable noise. The most widely used method is fountain with sound splashes.
Smell	Removing of offensive odours from the immediate environment as quickly as possible and provide other, more pleasant odours to supersede the noxious ones, such as vanilla, lavender, and mint.	1. Creation of flower gardens alongside the built environments. 2. Raised bed plantations for mint and scented flowers. 3. Covering of drainage lines and efficient disposal of storm and waste water .
Textures	Man is biologically set to deprive neurological nourishment from the varied textures that nature has provided. Most essential is the use of poly-culture in environments for stress relief as monoculture is irrelevant in nature also natural textures like of wood or stone is more preferable in context of neurological nourishment. Also the textures showcase the various colours and patterns that should be used in accordance of their neurological implications	1. **Green streets**- Don't automatically build low-density/low-speed roads out of asphalt, but instead use paving stones and gravel set into grass. 2. **Garden growing wild**- To be useful, a garden must be closer to growing wild, according to nature's rules, than conforming to an artificial image. 3. **Climbing plants**- A building connects to its surroundings when plant life grows into it, with the plants climbing up walls and trellises. 4. **Paving with cracks between the stones**- Paving stones laid directly onto earth, with gaps between them, allow growing plants to create a half natural environment.
Forms	The Biophilia Hypothesis suggests that man is intrinsically bond with natural forms with complex organic forms rather than plain monolithic elements and forms .Also man derives neurological nourishment from natural forms with multiple forms blended together to form complex geometries .The contemporary architecture has created much minimalistic forms than are required .	**1. Poly-culture**-Monoculture is inconsistent with the law of nature ,so the neurological interpretation of a lawn is equivalent to a concrete lab ,so gardens and lawns should be designed such that they replicate natural setting . **2. Avoiding Bio-mimicry** -Bio mimicry or organic forms of buildings are just poor interpretations of the natural elements ,they do not provide any significant neurological nourishment. The building should be designed such that it has substantial vegetation inside it along with ample of visual and physical connection with the properly designed outdoor environment.
Patterns	Whereas some design components are contextual (i.e. cultural, temporal, or location-specific), many are indeed universal. Christopher Alexander's *Pattern Language* codified evolved patterns of how humans interact with their environment and with each other. In Appendix A of this paper, I have summarized several Alexandrine patterns. The reader can readily see how these design patterns anticipate and support restorative or contemplative design. Architects can draw upon the *Pattern Language* , combining that helpful knowledge with the latest notions of human adaptivity into an innovative design .	**1. Accecssible greens**- Students, staff and teachers will only use green spaces when those are very close to where they live and work, accessible by a pedestrian path. **2. Half hidden garden**- For an outdoor environment to be used, it must not be too exposed by being out front, nor completely hidden by being in the back. **3. Tree places**- Trees shape social places, so shape buildings around existing trees, and plant new trees to generate a usable, inviting urban space. **4. Sacred sites-.** Identify and protect sites having extraordinary importance to the community, whether they are located in a built or green area.
Heat	Thermal comfort is an important factor while considering the design of an indoor or outdoor restorative environment. It should be taken into consideration that direct sunlight or glares must be screened	**Indoor environment** **1. Insulated building envelope**-The wall, roofs and openings in the building should have high insulation coefficient and should be airtight. **2. Proper ventilation**-The building rooms and spaces should have

	with the used of various design elements ,also the building envelope should have good thermal insulation and ventilation .The orientation of the building also plays an important role in this context	cross ventilation and access to outdoor air . **3. Passive cooling**-The building should be equipped with passive cooling techniques and equipments such as earth coil cooling ,solar chimneys etc. **4. Architectural features**-Pergolas, overhangs etc. that restricts direct sunlight into the building must be used. **5. Building orientation**-Large openings and punctures of the buildings should be oriented on the northern or eastern face . **Outdoor environment** **1.Large foliage trees**-Trees are natural heat controllers as they provide shade and cooling effect **2. Pools and streams**-Natural streams, ponds not only provide neurological nourishment but are also temperature regulators in an outdoor environment.
Proprio-ception	The knowledge of this science with the use of ergonometric data should be used in designing the elements and features for human comfort.	**Garden seat-** One cannot enjoy a garden if it does not have a comfortable seating arrangement in a semi-secluded place to sit and contemplate the plant growth.

8. CONCLUSION

The paper analyses the various architectural components present in the indoor and outdoor spaces that have a significant impact on the healing process .The recent findings in the field of neuro-architecture has given evidences regarding the effect of these elements and factors on the healing and the translation of these evidences into designs can help render effective solutions regarding creation of healing spaces .My thesis topic 'Design of Rejuvenation Centre' shares many attributes of designing with the healing spaces ,hence this study will help me in my thesis in the following ways;

1) Developing a thorough understanding of the impact of various perceived design and environmental elements on the healing or rejuvenation process.

2) Understanding the nature of these elements in context of stress relief, mental fatigue, attention restoration etc.

3) Designing is backed with the scientific evidences provided from the study of neuro-architecture.

4) Deduction of the quantitative and qualitative attributes for these factors .

5) Improvised or new elements in designs are derived from the understanding of the nature and implications of these elements.

6) The designed space would address the need of each and every sensory organ.

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