

Neuropsychological

Trends

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Review study on neuropsychological impact of ecotherapy on urbanization

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ABSTRACT

The following research is a review paper to determine what neurobiological changes occur during ecotherapy that impacts our behavior and what are its implications over urbanization. The research utilizes the selection of relevant literature across databases on the basis of their applicability in Indian context and publication date not exceeding beyond 10 years. The analysis of the 11 research articles reviewed reveals that the practice of ecotherapy has the positive impact on the brain by improving cognitive functions, attention span, inducing more relaxation and emotional wellness on a physiological level. Urbanization, on the other hand, has been documented to negatively impact cognitive function, response behavior, attentional tasks and metabolic processes due to excessive exposure to urban determinants. Therefore it can be concluded that eco therapeutic interventions can have positive impact and elicit improvement in psychological and physiological determinants of health and well-being.

Keywords: ecotherapy; neuropsychological; brain; urbanization

1. INTRODUCTION

Ecotherapy has been defined as an umbrella term under applied ecopsychology for treatments that involve healing and growth in a natural environment (Buzzell & Chalquist, 2009). Hill in 1999 described ecopsychology as “encompassing the human psychological relationship with nature in both directions” (Shams, 2005). Ecopsychology has been explored to study the relationship between organisms and their environment to their brain and behavior (Van der Heyden, 2004). It examines the evolutionary background of how humans relate to the natural world around them as well as the psychological factors that contribute to the formation of this relationship. Various paradigms have been explored to establish the impact that environment and nature around us have on physical, psychological and spiritual well-being of our health. Ecosystem has been defined as “Material building block of human well-being” (Russell et al., 2013). Knowing nature and experiencing it has been linked to a happier lifestyle and impacting decision making towards both people and ecosystem (Russell et al., 2013). It is clear from the data obtained during a multi-year, community-driven initiative in Rigolet, Nunatsiavut, Labrador, Canada, that the emotional effects of climate change are quite significant to people. The study’s participants reported that the changes in land, snow, ice, and weather caused them to experience fear, anger, despair, anxiety, and depression. They also have an impact on culture, self-worth, and health (Cunsolo Willox et al., 2013).

Ecotherapy is viewed to impact cognition due to interaction that occurs between the body and the environment. Various neuroscience studies revolve around the role of the environment in the development of attachment styles due to changes in our physiological mechanisms. In a study done in 2021 by Turtonen and colleagues, PET (Positron emission tomography) scans were used to establish that secure attachment style was linked to higher μ -opioid receptor availability in the hippocampus, amygdala, thalamus and prefrontal cortex (Turtonen et al., 2021). Later sections of this paper determine the role of nature as well in these areas, suggesting scope of research to explore the relationship between attachment style and environment.

Cortisol released in our body helps in emotional response formation by an individual which can be linked to maintenance of hormonal balance in a newborn baby when exposed to a natural environment involving skin to skin interaction with the parents (Levine et al., 2007). “Ecological Unconscious”, given by (Roszak, 2001) describes the need to sympathetically bond with nature around us in order to be fully conscious. This as an aspect of consciousness has been studied to be weakened by modernization and industrialization involving urbanization (Levine et al., 2007; Roszak, 2009).

Urbanization has been defined as growth of cities as a part of industrialization and economic development leading to specific changes in lifestyle, behavior and labor division. It is an involuntary and unavoidable demographic migration that cannot be neglected (Srivastava, 2009). The lifestyle changes involved in urbanization have been reflected by various studies to explore the effects on human brain and behavior. The built-in environment due to urbanization has led to an increase in stress levels along with a decrease in task ability and motivation (Baum et al., 1982). Increased noise levels in urban cities have been associated with impact problem solving skills (Boman, 2004) and depression (Gatchel et al., 1977). Feelings of alienation and restlessness have increased as a result of people's increased reliance on technology and decreased engagement with the natural world (Baum et al., 1982).

The impact of urbanization on neurophysiological aspects of health cannot be neglected and its impacts can be stressed as a part of development of various psychological disorders. Schizophrenia is considered a neurodevelopmental disorder and its vulnerability is linked to genetics that brings us back to the debate of nature vs. nurture (Boman, 2004; Lederbogen et al., 2011). Various stressors that cause social stress have been found to impact amygdala activity associated with anxiety disorders, depression, and other aggressive behaviors that have increased in cities (Boman, 2004; Lederbogen et al., 2011). However, recent interventions involving interactions with nature and the environment around us have been seen to intervene positively against the harmful effects of urbanization. Ecopsychology has thus acted as a response to the crisis faced against alienation of individuals from nature (Van der Heyden, 2004).

This study attempts to explore the changes in our brain that accompany the process of urbanization. Considering the modern impact of ecotherapy on the lives of individuals in cities, the study attempts to link the changes observed in the brain due to ecotherapy to those during urbanization and develop a theoretical cohort of existing literature that attempts to explain the neuropsychological impact of ecotherapy on urbanization. The study thoroughly explores 11 existing literature as part of descriptive research to answer the following research questions (i) What are the changes observed in the brain due to the practice of ecotherapy? (ii) What are the changes observed in the brain due to the phenomenon of urbanization? (iii) What is the impact of eco therapeutic interventions on brain changes caused due to urbanization?

2. METHODOLOGY

2.1 Eligibility criteria

The following research involved inclusion of literature that was published and existing over the databases. The literature selected for analysis was published not before 10 years from the current research as urbanization has been a long procedure undergoing periodical changes over the years. A study in Singapore analyzed 11 ecosystem services over the span of rapid urbanization that the city underwent and established that urbanization decreased the reliance of people on gaining raw materials from the local ecosystem (Richards et al., 2020). Urbanization can therefore be conceptualized as a concept for analysis over a very long period of time due to significant changes as a scope of this study. A period of 10 years allows for sufficient coverage of changes and time-based studies to be included as well as allowing for research data to not be outdated and still relevant to current scenarios. The language of literature referred to was strictly English even though the data analyzed was from different geographical areas. This was maintained to keep the language assessment the same for prevention of bias in understanding the literature. It has been made sure that analyses involve literature focused on urban population as the lifestyle differences between rural and urban populations wouldn't allow for clear identification between factors relevant to urban population. The selection of literature was also not focused on use of psychotherapy and ensuring the literature selection was more focused on neuropsychological aspects rather than the clinical population.

2.2 Database utilization and search strategy

This research utilized various databases for searching the literature relevant to the study. Databases namely Google Scholar, Directory of open access journals, EBSCO and JSTOR were used to search and gain access to relevant literature for the study. While searching the databases, various keywords were utilized that were considered relevant to the nature and scope of the present study. The major keywords used were ecotherapy, neuropsychological, brain and urbanization.

The articles referred to in the study were also found in the references mentioned in the other relevant research. Table 1 provides detailed information regarding the keywords involved in searching the relevant literature along with the date of publication for eligibility criteria.

The selection strategy for the research included defining the presence of

keywords in the relevant literature. The literature was thoroughly analyzed to adhere to eligibility criteria. The collected studies were reviewed to create themes relevant to the scope of the study.

3. RESULTS

The literature collected for this part of the review was thoroughly read and analyzed in order to provide insights covered by the scope of the study. This section covers various themes described and linked on the basis of existing literature along with a summary for the same presented by Table 1.

Table 1. References, Year of publication, Keywords and Themes

S.No	Title of the reference	Year of publication	Keywords utilized	Identified themes
1.	Nature-based Regenerative Healing: A case-study of interpersonal ecotherapy (Puk, 2021)	2021	Ecotherapy, neurobiology	Effect of ecotherapy on the brain, ecotherapy and healing, Role of the brain in healing
2.	Being there: Implications of neuroscience and meditation for self-presence in virtual worlds (Heeter & Allbritton, 2015)	2015	Ecotherapy, neurobiology	Role of meditation in ecotherapy, AI and meditation and ecotherapy, changes in brain due to meditation
3.	Ecotherapy: Healing ourselves, Healing the Earth (Clinebell, 2013)	2013	Ecotherapy, Healing	Healing and ecotherapy
4.	Ecotherapy–A forgotten ecosystem service: A review (Summers & Vivian, 2018)	2018	Changes in the brain during ecotherapy	Role of ecotherapy in neural changes, ecology and brain, introduction of ecotherapy to urban setting
5.	Your brain on nature: The science of nature's influence on your health, happiness, and vitality (Selhub & Logan, 2013)	2012	Ecotherapy and the brain	Changes in the brain due to nature, nature and health
6.	Green mind theory: how brain-body-behavior links into natural and social environments for healthy habits (Pretty et al., 2017)	2017	Ecotherapy and the brain	Society and environment, ecotherapy effect on brain, body, behavior, role of natural and urban settings on brain and behavior
7.	Brains in the city: Neurobiological effects of urbanization (Lambert et al., 2015)	2015	Urbanization and the brain	Effects of urbanization on the brain, urban determinants, urban lifestyle issues and brain

8.	Environmental Neuroscience (Berman et al., 2019)	2019	Urbanization and Neuroscience	Neuroscience, urban lifestyle, natural setting environment, green space inclusion
9.	Cities and neuroscience research: A systematic literature (Ancora et al., 2022)	2022	Urbanization and Neuroscience	Urban lifestyle and the need for a natural environment
10.	Impact of urbanization on cognitive disorders (Kosanic & Petzold, 2020; Robbins et al., 2019)	2019	Urbanization and Neuropsychology	Brain and cognitive disorders and urbanization impact
11.	A systematic review of cultural ecosystem services and human wellbeing(Kosanic & Petzold, 2020)	2020	Culture, urbanization, mental health	Interaction between culture and environment and their role in impacting brain and behavior and its utilization in urban setting

3.1 Effects of Ecotherapy on the brain

Ecotherapy has been embraced by psychology as an area that links ecology to it and helps in holistic development across theories and practice (Buzzell & Chalquist, 2009). Natural settings provide an embodied experience in healthy surroundings. Trees have been evidenced to act as filters in forests, helping capture dust and toxins along with emission of aromatic phytoncides that kill germs and increase oxygen levels in the atmosphere (Wohlleben, 2016). Walking through forests has been linked to lower blood pressure, improved lung capacity, increased elasticity of arteries and increased relaxation (Song et al., 2016). The neurotransmitters essential for healing are also produced during natural processes (Selhub & Logan, 2013). Healing neurotransmitters are also stimulated by the sunlight (Ha & Shao, 2021).

Eco therapeutic techniques like Eco-art Movement (Kopytin, 2017) involve deliberate targeted thought processes to focus on the natural environment and connect in order to alter neuronal structures already established by faulty learning patterns. These alterations occur during the formation of new neurons, formation of synapses, or new connections to develop new neural pathways, or when myelin sheath is thickened and strengthened around the neuron. Natural settings help in these alterations by

inducing changes in faulty learning patterns (Coyle, 2003). The messenger molecules are peptides stimulated by emotions that carry information across our body (Chopra & Tanzi, 2017; Ulrich et al., 1991). Barrett in 2017 gave a theory of constructed emotion that postulated the construction of emotion by the brain on the basis of past experiences and sensory feedback on the basis of current experiences. It concluded that emotions are involved in strengthening brain connections. These emotional concepts and responses can be reshaped by the assistance of the natural environment that has healing properties. These changes in faulty learning patterns induced due to ecotherapy can be utilized in therapeutic treatment styles like CBT. The natural environment can alter past neural connections and help reshape traumatic experiences for better lifestyle changes.

Interaction and direct contact with nature has been associated to have a positive impact on affective, cognitive, and moral development of children (Kahn & Kellert, 2002). Children who were allowed to interact with outdoor environments have an increased cognitive functioning highlighting the benefit of interaction with the ecosystems. Interactions with nature have been recorded to influence directed attention (Hartig et al., 1991), information processing effectiveness (Hartig et al., 1991), cancer patient enhanced effectiveness recovery (Cimprich, 1992; Hartig et al., 1991) and attentiveness (Tennessen & Cimprich, 1995). Thus introduction to ecological changes positively affects brain mechanisms. These changes in case of children can be utilized to enhance academic performance and develop an environment for holistic development of brain.

Tsunetsugu et al. in 2007 conducted a study in Japan to observe the impact of nature on our physiological mechanisms. They observed that walking through the forest activated the prefrontal cortex that lowered the blood cortisol level along with blood pressure, strengthened the immune system and promoted muscle relaxation. The sympathetic nervous system activity was suppressed along with enhancement in activity of parasympathetic nervous activity lowering the stress of the participants (Park et al., 2007; Tennessen & Cimprich, 1995; Tsunetsugu et al., 2007). The study concluded that passive exposure to nature can be linked to positive impact on attention, memory and mood (Norwood et al., 2019).

The impact that ecotherapy has on the brain can be linked to improvements on specific parts of the brain. Brain areas namely dorso-prefrontal cortex, hippocampus and amygdala are affected by techniques involving ecotherapy. The impact on synaptogenesis and emotional regulation are key concepts of focus towards the efficacy of ecotherapy that can therefore be utilized to strengthen brain processes and mechanisms. The changes that are highlighted by this section to occur in the brain play an important role in

development of lifestyle and overall holistic development of an individual. Thus, the role of ecotherapy on brain mechanisms and processes can be linked to each other on the basis of this section.

3.2 Effects of urbanization on the brain

Neourbanism has emerged as a discipline of neuroscience that emphasizes theoretical perspectives and analysis of neuroscience to contribute to urban planning and design (Pykett et al., 2020). MacLean in 1973 gave the Triune brain theory that explains brain functioning on the basis of three evolutionary perspectives. The first perspective identifies the Reptilian Brain as the oldest perspective which operates on the flight or fight response mechanism. The second perspective of the Mammalian Brain identifies with that of nurturing and caring instinct. The last perspective describes the recent development of Neocortex to represent the ability of reasoning and long term planning. The three perspectives represent centers that help respond to threat, injury, illness or trauma (Rice, 2012). These three perspectives help shape how human brain learns and functions and therefore provide an insight towards development of brain and primal processes in an urban society.

The brainstem is the most primitive structure in the brain and works on the survival instinct. It helps respond fast, involuntary, automatic, impulsive, driven by emotions, and execute habits and routines. The midbrain consists of the hippocampus, hypothalamus and thalamus, and amygdala and helps regulate emotions, memory forming, and bonding (Pretty et al., 2017). Evolution has allowed the top brain cortex to have expanded rapidly in size that makes it slower, voluntary, able to learn and plan, make internal choices, and contains centers for the social abilities of empathy and language. It drives the parasympathetic nervous system to create a calming effect on the principle of rest and digest. The amygdala fires the bottom brain to action to drive the sympathetic nervous system (SNS) via the hypothalamus pituitary adrenal axis (HPAA) leading to the fight-and-flight response. The brain mediates via complex neural circuits and mechanisms how we respond to environmental stress and maintain homeostatic control. It helps in determination and identification of threat and various behavioral and physiological adaptive responses. All these processes can be linked to affect how our primitive brain that has developed from the natural settings responds to urban changes in infrastructure and lifestyle (Pretty et al., 2017).

Anxiety as a disorder has been highlighted as an issue prevalent in current urban society. Development of anxiety has been linked to brain region interactions between the amygdala, prefrontal cortex, anterior cingulate cortex, and hippocampus that are associated with fear conditioning and extinction.

Abnormalities in prefrontal cortex and anterior cingulate cortex might affect their connections to the amygdala leading to weakening of top down functioning in the brain (Cohodes & Gee, 2017; Pretty et al., 2017).

Urban civilization exposes individuals to more air pollution and traffic pollutants which have been linked to higher risk of developing dementia (Clifford et al., 2016). Urban regions with over-stimulating or under-stimulating infrastructure had greater risk for cognitive impairment (Clifford et al., 2016; Robbins et al., 2019). The heavy noise and pollution generated due to increase in traffic in residential areas has been proven to lead to higher incidences of dementia (Chen et al., 2017). The brain circadian rhythm is affected in urban lifestyle due to increased exposure to night light leading to impaired affective response. Neuroimaging has helped us identify brain structure activation as a response to fearful stimuli that includes amygdala hyperactivation relating to PTSD (Post Traumatic Stress Disorder) (Shin et al., 2006). Urban lifestyle exposes women to fearful trauma which was studied during fMRI (Functional Magnetic Resonance Imaging) scans in which survivors were exposed to fearful facial expression. The results demonstrated greater amygdala activation signifying development of PTSD (Stevens et al., 2013).

Technology allows the brain to gain fast boosts. However, these fast boosts can result in inhibition fatigue. Inhibition conducts cognitive functions, and this brain energy is used towards technology which distracts the energy to be utilized towards important attentional tasks. While using technology, the brain exerts lots of effort but in wrong ways (Selhub & Logan, 2013). Typically, urban settings have been deemed to be more discomforting affecting metabolic processes and well-being in individuals. The research sheds light on the effects of urban living on metabolic syndrome, which can have implications for brain metabolism. Unhealthy diets and physical inactivity, which are common in urban areas, not only contribute to metabolic syndrome but can also lead to cognitive decline and hinder brain metabolism. Additionally, stress and environmental factors such as air and noise pollution prevalent in urban areas have been associated with an increased risk of neurodegenerative diseases (Hong et al., 2017). Thus, the importance of promoting healthy behaviors and lifestyles in urban areas to optimize both metabolic and brain health is essentially highlighted.

Inactive and sedentary lifestyle has contributed to increase in anxiety, guilt and stress. It has become easier to develop habits that promote overeating, drinking or reliance on pharmaceutical interventions. Researchers have established such cultures to have more lonely individuals. They display higher levels of cortisol and epinephrine along with high blood pressure. They have more active SNS-HPAA which leads to poorer sleep and immune functions,

accelerating physiological decline with age (Hawkey & Cacioppo, 2007; Pretty et al., 2016). Urbanization exposes us to different sizes of social circle. Being part of a small social circle has been associated with smaller amygdala and hippocampus affecting social behavior (Pretty et al., 2017).

The impact of urbanization has been linked to various negative effects on the brain and therefore utilization of ecotherapy and its efficacy in an urban setting is being explored by literature in the next section.

3.3 Role of ecotherapy on the brain

Environmental psychologists discuss the disconnection between humans and nature as the root cause of psychological and physical problems in a modern society. This lack of contact with nature has been associated with psychosocial stress experienced by children and adults (Mathias et al., 2020).

Environmental neuroscience is the scientific study of bidirectional relationships mediated by the brain between organisms and their natural environment. Research shows that the human brain can undergo physical and functional changes in response to physical environmental stimuli (Berman et al., 2008; Louv, 2013). Additionally, cultural learning can lead to the formation of new neural connections in the brain (Dehaene et al., 2010). Studies have also demonstrated changes in the white matter tracts of children who were exposed to air pollution (Pujol et al., 2016). These findings together highlight the important role that the environment can play in shaping the structure and function of the brain. In a study, Miligram in 1970, recognized a bidirectional pathway between humans and the environment (Milgram, 1970). We as humans are responsible for creating our environment around us and subsequently this environment changes us. Urbanization promotes sociophysical boosts to infrastructural economies as well as creativity however it also plays a role in promoting crime, pollution, and suicide rates (Berman et al., 2019). These two paradigms are focused on the development of interventions that can create a positive impact on the environment, leading to an overall positive impact on human beings. These perspectives emphasize the importance of improving our environment in order to improve our own well-being.

In the context of development of school, researchers establish that natural exposure indicates optimal student learning and wellness (Corazon et al., 2019). When interventions are introduced in early childhood by exposing children to activity in natural places, their cognitive outcomes were observed to increase (playgrounds, gardens, and woodlands) (Bratman et al., 2012; Corazon et al., 2019). Hence, ecotherapy could be utilized in urban school settings to enhance educational benefits and holistic development.

The psychoevolutionary theory emphasizes the calming effect and stress

reduction offered by the natural environment that helps in emotional regulation. It positively impacts to enhance feelings of emotional well-being by reducing neurophysiological aspects of stress, positive emotion generation, increasing attentiveness and controlling negative thoughts (Hartig et al., 1991; R. Kaplan & Kaplan, 1989; Naor & Maysseless, 2021). The arrangement and construction of human settlements have been identified as a crucial factor that affects the health and well-being of individuals. Consequently, the incorporation of natural spaces in urban infrastructure can be considered a vital step towards developing healing environments in cities.

Attention Restoration theory suggests that the natural environment helps to promote recovery from stress and fatigue by restoring attention mechanisms (S. Kaplan, 1995; Ulrich et al., 1991). Similarly, Biophilia theory emphasizes on responses of the brain to reflect more pleasure and relaxation when exposed to natural settings due to inherent natural affinity towards the environment (Kellert & Wilson, 1995). In a study by Kim et al., brain activity was compared by exposing participants to pictures of natural landscapes. Brain activity with greater alpha waves, associated to meditative and relaxed state, was observed in the frontal (particularly in the superior and middle frontal gyrus), parietal (in the superior parietal gyrus), precuneus and anterior cingulate cortex regions that determined experience of comfort. However, when exposed to urban setting stimulus, brain activity was observed in temporal regions (anterior temporal pole, hippocampus, and parahippocampal gyrus), occipital cortex (predominantly the middle occipital gyrus) and amygdala due feelings greater suffocation (Ancora et al., 2022).

Interactions associated with nature increase working memory capacity, help in mood regulation, and increase attention (Berman et al., 2019). Long term exposure to natural settings reduces crime rates (Kuo & Sullivan, 2001). EEG (Electroencephalography) studies involving perception of images with fractal stimulation similar to nature allows the brain to go in a low-effort state (Hagerhall et al., 2015). Studies done on non-human species show that group of neurons found in the retina have the ability to encode information for natural settings differently than that of an artificial setting (Tkačik et al., 2015). Neurocognitive restoration accessed by individuals from green spaces allows them to interact more positively than others (Kuo & Sullivan, 2001).

Cubicle Ninjas Costa del Sol beach environment was an experimental meditation design developed to explore the potential of meditation to affect embodied presence. It allowed us to understand the role of natural mediation and its effect on our brain is positive (Heeter & Allbritton, 2015). Reese and Myers in 2012 developed the Eco-wellness framework that incorporates nature strategically into the school environment (Reese & Myers, 2012). It allows one to develop appreciation, respect and awe for nature and helps connect to nature

and holistic wellness at a deeper level (Reese et al., 2018).

EEG studies were used to monitor emotions of participants while walking in nature. It was found that the brain waves, alpha waves, were similar to those observed during meditation. When compared to those of a busy or bustling shopping street, individuals exhibited less frustration in a greenspace area (Reese et al., 2018; Roe et al., 2013). Alteration in urban environment to include greenspaces would reduce mood and anxiety disorders as well as impact by reducing poverty concentration, social cohesion and social control. Green spaces are unequally divided between inhabitants of urban settings. Natural environmental elements have neurobiological impacts which are distinctly apart from those observed under artificial stimuli (Liang et al., 2022). For example, recovery from stress is faster when individuals are shown stimuli involving natural stimuli rather than a traffic environment (Ulrich et al., 1991).

Motor activity was observed to be increased in rats that were rare outdoors which points towards free play for children outdoors. Prefrontal cortex activity has been seen to increase following exposure to the natural environment. Cognitive restoration is benefitted by the natural environment as it helps in reshaping brain cells and plasticity and improves cognition (Selhub & Logan, 2013). Hence the literature focuses and highlights the role of eco therapeutic interventions and how it could be beneficial towards promotion of neuro urbanism along with making urban cities psychologically healthy.

4. DISCUSSION

Ecotherapy views the mental health and behavior of an individual in the context of nature and natural phenomenon across ecosystems (Clinebell, 2013; Swimme, 1994). Psychoevolutionary theory was developed that suggested that emotional response of an individual could be regulated by exposing themselves to a natural environment that reduces stress and induces calming effect (Hartig et al., 1991; R. Kaplan & Kaplan, 1989; Naor & Maysseles, 2021). Brain activity was measured by Ulrich in 1991 using EEG and fMRI for unstressed healthy adults to conclude that exposure to natural landscapes led to increased production of serotonin in individuals (Ulrich et al., 1991). This suggests utilization of the eco therapeutic techniques as an application for treatment involving depression and mood disorders.

Food overconsumption is a leading issue in affluent countries that is a cause for the current generation to face many health changes (Hawkley & Cacioppo, 2007; Pretty et al., 2016). These lifestyle changes in urban environments impact an individual's cognitive development in both positive

and negative ways. Cognitive Disorder research that links these health changes to urbanization suggesting that urban lifestyle reduces the chance of development of any cognitive disorder due to availability of better resources, educational awareness and advanced stimulus (Abner et al., 2016). However, in another study, Louv, used the term Nature Deficit Disorder to describe the impact on the young generation seen due to sedentary lifestyle and less exposure to natural outdoor environments. The disorder focuses on development of physical mental concerns like obesity, depression, anxiety, ADHD (Attention Deficit Hyperactivity Disorder) as a result of deprivation from natural environment (Louv, 2013). Both these research focus on the two sides of the same coin focusing on aspects of urbanization and how less exposure to the natural environment impacts our health even though urban resources make it manageable.

As humans we interact with the environment around us. It impacts our mental health as well as influences our behavior. A study highlights how an individual's mental health needs are affected by the natural environment and how various neurological changes that occur due to nature shape our behavior. It helps connect individuals to ecosystems as a part of them rather than as separate entities (Jones, 2010; Totton, 2011). Ecotherapy helps people connect with nature in order to deal with physical or mental illness (Buzzell & Chalquist, 2009). It helps in healing while in a natural environment. Ecotherapy can also be linked to documentation of emotional benefits for spending time in a natural setting. Pleasant feelings like calmness, harmony or increase in energy and vitality have been recorded as emotions felt in natural environment (Ulrich et al., 1991). These emotions promote well-being for individuals and increase in overall health as a holistic concept.

Brain processing that occurs at an unconscious level can be influenced at a conscious level by involving techniques like meditation and artful mindfulness. These techniques help increase attention and awareness along with well-being in individuals. Attention restoration theory was developed in 1989 that proposed the restoration and redirection of attention to tasks at hand by introduction of contact to nature. It emphasizes on clearing the mind, redirecting attention, dealing with unresolved concerns, and reflecting on priorities in presence of a supportive environment in a natural setting (R. Kaplan & Kaplan, 1989; Hartig et al., 1991). This allows the foundation of mindfulness and art meditation techniques involving green and natural spaces to enhance effectiveness of these techniques.

Artificial intelligence research has shown that computer-based networks, which simulate mammalian central nervous system functions, are affected by environmental changes (Maniadakis & Trahanias, 2006). These simulation techniques can be used to study the impact of the natural environment on

brain development and changes. A study was conducted in Berkeley that exposed rats to natural settings outdoors and studied them to conclude development of heavier brains in comparison to rats that were reared indoors (Rosenzweig & Bennett, 1972). The study suggests a universal mechanism towards positive reactions received by the brain when stimulated in a natural setting which could be utilized in an urban setting for better outcomes.

The Yoga Sutra of Patanjali has established a meditation tradition that practices to regulate the human system and help the brain become more receptive by refining the taste of mind. These meditation techniques have been developed keeping in mind natural ingredients and maximizing exposure to nature. Yoga camps organized focus explicitly on connecting with nature using mindfulness techniques hence, impacting the welfare of individuals in a natural setting and allowing space for healing processes (Heeter & Allbritton, 2015).

The literature allowed dwelling on ways in which the natural environment can be linked to brain development and how urban settings can be integrated with natural spaces to allow holistic development and healing along with a balanced lifestyle.

5. CONCLUSION

The study focused on finding answers to the research questions implied in the beginning of the research via exploration of already existing literature to determine: (i) What are the changes observed in the brain due to practice of ecotherapy? (ii) What are the changes observed in the brain due to the phenomenon of urbanization? (iii) What is the impact of eco therapeutic interventions on brain changes caused due to urbanization?

The study answers the practice of ecotherapy to have a positive impact on the brain by improving cognitive functions, attention span, inducing more relaxation and emotional wellness on a physiological level. Urbanization on the other hand has been documented to negatively impact cognitive function, response behavior, attentional tasks and metabolic process due to excessive exposure to urban determinants. The role of ecotherapy has therefore been highlighted in urban settings as an answer to the third research question to establish that eco therapeutic interventions can have positive impact and elicit improvement in psychological and physiological determinants of health and well-being. This review study concludes that physical environment and nature contribute towards changes in the brain that can be incorporated in urbanization models for holistic neuropsychological development of an individual.

The current study sheds light on the neuropsychological role of ecotherapy in urbanization. The literature referred to implicates the positive impact of eco therapeutic techniques on brain physiology and mechanisms. This allows us to delve into utilization of these techniques as a part of urbanization and develop changes in the urban environment to incorporate more eco therapeutic interventions. Development of green spaces and their effect on brain development has been deemed positive by researchers. Studies involving eco-wellness programs in school curriculum have benefited young students to develop better cognitive functioning highlighting the positive impact of ecotherapy on urbanization. Various neuroimaging techniques EEG and fMRI support the evidence of eco therapeutic techniques like nature walk or eco-art movement therapy as an effective intervention in urban lifestyle for neuropsychological development. Practical identification of implications of study highlights the design of urbanization models that cater to holistic development. The study answers the relevant research questions by effectively determining the impact ecotherapy and urbanization have on the brain mechanism and processes as well as establishing a theoretical link between utilization of eco therapeutic techniques in urban spaces.

5.1 Limitations

The current study limits itself in consideration of determinants relevant to psychological disorders and abnormal psychology. Criteria for abnormal psychology and psychological psychology can be used to advance the study towards determining utilization of eco therapeutic interventions in treatment. The research also fails to include scope of architectural changes impacting the variables. Various architectural designs and color schemes can be used to elaborate the interventions required for well-being and psychopathological treatments. Further scope of research can also include determining developmental impacts of urbanization and eco therapeutic interventions relevant to specific culture and age group. It would allow design specific interventions according to age groups and gender specific designs. Various cultural factors can also be a part of intervention design for various ethnic groups.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, Shukla G., upon reasonable request. Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Ethic Statement

I, Gargi Shukla, solemnly declare that the manuscript titled “Review Paper on Neuropsychological Impact of Ecotherapy on Urbanization” rigorously adheres to these principles: 1) This material embodies the authors’ genuine contributions, devoid of prior publication. 2) Simultaneous consideration by other publications does not apply. This work maintains scholarly ethics, upholding transparency, integrity, and the spirit of original research.

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Competing Interests

The author declares no competing interests associated with the publication of this review paper.

Authors contribution

In this review paper, I, the sole author, conducted extensive literature analysis, critical synthesis, and conceptual framework development. The entirety of the manuscript, including content refinement and final approval, reflects my dedicated scholarly effort and commitment to this work.

REFERENCES

- Abner, E. L., Jicha, G. A., Christian, W. J., & Schreurs, B. G. (2016). Rural-Urban Differences in Alzheimer's Disease and Related Disorders Diagnostic Prevalence in Kentucky and West Virginia. *The Journal of Rural Health, 32*(3), 314–320. <https://doi.org/10.1111/jrh.12155>
- Ancora, L. A., Blanco-Mora, D. A., Alves, I., Bonifácio, A., Morgado, P., & Miranda, B. (2022). Cities and neuroscience research: A systematic literature review. *Frontiers in Psychiatry / Frontiers Research Foundation, 13*, 983352. <https://doi.org/10.3389/fpsy.2022.983352>
- Baum, A., Calesnick, L. E., Davis, G. E., & Gatchel, R. J. (1982). Individual differences in coping with crowding: Stimulus screening and social overload. *Journal of Personality and Social Psychology, 43*(4), 821–830. <https://doi.org/10.1037/0022-3514.43.4.821>
- Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science, 19*(12), 1207–1212. <https://doi.org/10.1111/j.1467-9280.2008.02225.x>
- Berman, M. G., Stier, A. J., & Akcelik, G. N. (2019). Environmental neuroscience. *American Psychologist, 74*(9), 1039–1052. <https://doi.org/10.1037/amp0000583>
- Boman, E. (2004). The effects of noise and gender on children's episodic and semantic memory. *Scandinavian Journal of Psychology, 45*(5), 407–416. <https://doi.org/10.1111/j.1467-9450.2004.00422.x>
- Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health. *Annals of the New York Academy of Sciences, 1249*(1), 118–136. <https://doi.org/10.1111/j.1749-6632.2011.06400.x>
- Buzzell, L., & Chalquist, C. (2009). *Ecotherapy: Healing with Nature in Mind*. Counterpoint.
- Chen, H., Kwong, J. C., Copes, R., Hystad, P., van Donkelaar, A., Tu, K., Brook, J. R., Goldberg, M. S., Martin, R. V., Murray, B. J., Wilton, A. S., Kopp, A., & Burnett, R. T. (2017). Exposure to ambient air pollution and the incidence of dementia: A population-based cohort study. *Environment International, 108*, 271–277. <https://doi.org/10.1016/j.envint.2017.08.020>
- Chopra, D., & Tanzi, R. E. (2017). *Super Genes: Unlock the Astonishing Power of Your DNA for Optimum Health and Well-Being*. National Geographic Books.

- Cimprich, B. (1992). Attentional fatigue following breast cancer surgery. *Research in Nursing & Health*, 15(3), 199–207. <https://doi.org/10.1002/nur.4770150306>
- Clifford, A., Lang, L., Chen, R., Anstey, K. J., & Seaton, A. (2016). Exposure to air pollution and cognitive functioning across the life course--A systematic literature review. *Environmental Research*, 147, 383–398. <https://doi.org/10.1016/j.envres.2016.01.018>
- Clinebell, H. (2013). *Ecotherapy: Healing ourselves, healing the earth*. Routledge. <https://doi.org/10.4324/9781315799773>
- Cohodes, E. M., & Gee, D. G. (2017). *Developmental neurobiology of anxiety and related disorders*. In *Oxford Research Encyclopedia of Neuroscience*. Oxford University Press. <https://doi.org/10.1093/acrefore/9780190264086.013.129>
- Corazon, S. S., Sidenius, U., Poulsen, D. V., Gramkow, M. C., & Stigsdotter, U. K. (2019). Psycho-Physiological Stress Recovery in Outdoor Nature-Based Interventions: A Systematic Review of the Past Eight Years of Research. *International Journal of Environmental Research and Public Health*, 16(10), 1711. <https://doi.org/10.3390/ijerph16101711>
- Coyle, J. T. (2003). Use it or lose it--do effortful mental activities protect against dementia? [Review of Use it or lose it--do effortful mental activities protect against dementia?]. *New England Journal of Medicine*, 348(25), 2489–2490. <https://doi/pdf/10.1056/NEJMp030051>
- Cunsolo Willox, A., Harper, S. L., Edge, V. L., Landman, K., Houle, K., & Ford, J. D. (2013). The land enriches the soul: On climatic and environmental change, affect, and emotional health and well-being in Rigolet, Nunatsiavut, Canada. *Emotion, Space and Society*, 6, 14–24. <https://doi.org/10.1016/j.emospa.2011.08.005>
- Dehaene, S., Nakamura, K., Jobert, A., Kuroki, C., Ogawa, S., & Cohen, L. (2010). Why do children make mirror errors in reading? Neural correlates of mirror invariance in the visual word form area. *NeuroImage*, 49(2), 1837–1848. <https://doi.org/10.1016/j.neuroimage.2009.09.024>
- Gatchel, R. J., McKinney, M. E., & Kobernick, L. F. (1977). Learned helplessness, depression, and physiological responding. *Psychophysiology*, 14(1), 25–31. <https://doi.org/10.1111/j.1469-8986.1977.tb01149.x>
- Hagerhall, C. M., Laike, T., Küller, M., Marcheschi, E., Boydston, C., & Taylor, R. P. (2015). Human physiological benefits of viewing nature: EEG responses to exact and statistical fractal patterns. *Nonlinear Dynamics, Psychology, and Life Sciences*, 19(1), 1–12.

- Ha, H., & Shao, W. (2021). A spatial epidemiology case study of mentally unhealthy days (MUDs): air pollution, community resilience, and sunlight perspectives. *International Journal of Environmental Health Research*, 31(5), 491–506. <https://doi.org/10.1080/09603123.2019.1669768>
- Hartig, T., Mang, M., & Evans, G. W. (1991). Restorative effects of natural environment experiences. *Environment and Behavior*, 23(1), 3–26. <https://doi.org/10.1177/0013916591231001>
- Hawkey, L. C., & Cacioppo, J. T. (2007). Aging and loneliness: Downhill quickly?. *Current Directions in Psychological Science*, 16(4), 187–191. <https://doi.org/10.1111/j.1467-8721.2007.00501.x>
- Heeter, C., & Allbritton, M. (2015). Being there: Implications of neuroscience and meditation for self-presence in virtual worlds. *Journal of Virtual Worlds Research*, 8(2). <https://doi.org/10.4101/jvwr.v8i2.7164>
- Hong, S.-H., Shin, D.-C., Lee, Y.-J., Kim, S.-H., & Lim, Y.-W. (2017). Health risk assessment of volatile organic compounds in urban areas. *Human and Ecological Risk Assessment: An International Journal*, 23(6), 1454–1465. <https://doi.org/10.1080/10807039.2017.1325714>
- Jones, P. (2010). Roosters, hawks and dawgs: Toward an inclusive, embodied eco/feminist psychology. *Feminism & Psychology*, 20(3), 365–380. <https://doi.org/10.1177/0959353510368120>
- Kahn, P. H., Jr, & Kellert, S. R. (2002). *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations*. MIT Press.
- Kaplan, R., & Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. Cambridge University Press.
- Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, 15(3), 169–182. [https://doi.org/10.1016/0272-4944\(95\)90001-2](https://doi.org/10.1016/0272-4944(95)90001-2)
- Kellert, S. R., & Wilson, E. O. (1995). *The Biophilia Hypothesis*. Island Press.
- Kopytin, A. (2017). Environmental and ecological expressive therapies. In *Environmental Expressive Therapies* (pp. 23–47). Routledge.
- Kosanic, A., & Petzold, J. (2020). A systematic review of cultural ecosystem services and human wellbeing. *Ecosystem Services*, 45, 101168. <https://doi.org/10.1016/j.ecoser.2020.101168>
- Kuo, F. E., & Sullivan, W. C. (2001). Environment and crime in the inner city: Does vegetation reduce crime?. *Environment and Behavior*, 33(3), 343–367. <https://doi.org/10.1177/0013916501333002>

- Lambert, K. G., Nelson, R. J., Jovanovic, T., & Cerdá, M. (2015). Brains in the city: Neurobiological effects of urbanization. *Neuroscience and Biobehavioral Reviews*, *58*, 107–122. <https://doi.org/10.1016/j.neubiorev.2015.04.007>
- Lederbogen, F., Kirsch, P., Haddad, L., Streit, F., Tost, H., Schuch, P., Wüst, S., Pruessner, J. C., Rietschel, M., Deuschle, M., & Meyer-Lindenberg, A. (2011). City living and urban upbringing affect neural social stress processing in humans. *Nature*, *474*(7352), 498–501. <https://doi.org/10.1038/nature10190>
- Levine, A., Zagoory-Sharon, O., Feldman, R., Lewis, J. G., & Weller, A. (2007). Measuring cortisol in human psychobiological studies. *Physiology & Behavior*, *90*(1), 43–53. <https://doi.org/10.1016/j.physbeh.2006.08.025>
- Liang, X., Lu, T., & Yishake, G. (2022). How to promote residents' use of green space: An empirically grounded agent-based modeling approach. *Urban Forestry & Urban Greening*, *67*, 127435. <https://doi.org/10.1016/j.ufug.2021.127435>
- Louv, R. (2013). *Last Child in the Woods: Saving our Children from Nature-Deficit Disorder*. Atlantic Books Ltd.
- Maniadakis, M., & Trahanias, P. (2006). Modelling brain emergent behaviours through coevolution of neural agents. *Neural Networks*, *19*(5), 705–720. <https://doi.org/10.1016/j.neunet.2005.02.007>
- Mathias, S., Daigle, P., Dancause, K. N., & Gadais, T. (2020). Forest bathing: a narrative review of the effects on health for outdoor and environmental education use in Canada. *Journal of Outdoor and Environmental Education*, *23*(3), 309–321. <https://doi.org/10.1007/s42322-020-00058-3>
- Milgram, S. (1970). The experience of living in cities: A psychological analysis. In F. F. Korten, S. W. Cook, & J. I. Lacey (Eds.), *Psychology and the problems of society* (pp. 152–173). American Psychological Association. <https://doi.org/10.1037/10042-011>
- Naor, L., & Mayselless, O. (2021). The art of working with nature in nature-based therapies. *Journal of Experimental Education*, *44*(2), 184–202. <https://doi.org/10.1177/1053825920933639>
- Norwood, M. F., Lakhani, A., Maujean, A., Zeeman, H., Creux, O., & Kendall, E. (2019). Brain activity, underlying mood and the environment: A systematic review. *Journal of Environmental Psychology*, *65*, 101321. <https://doi.org/10.1016/j.jenvp.2019.101321>
- Park, B.-J., Tsunetsugu, Y., Kasetani, T., Hirano, H., Kagawa, T., Sato, M., & Miyazaki, Y. (2007). Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest)--using salivary cortisol and cerebral activity as

- indicators. *Journal of Physiological Anthropology*, 26(2), 123–128.
<https://doi.org/10.2114/jpa2.26.123>
- Pretty, J., Barton, J., Bharucha, Z. P., Bragg, R., Pencheon, D., Wood, C., & Depledge, M. H. (2016). Improving health and well-being independently of GDP: dividends of greener and prosocial economies. *International Journal of Environmental Health Research*, 26(1), 11–36.
<https://doi.org/10.1080/09603123.2015.1007841>
- Pretty, J., Rogerson, M., & Barton, J. (2017). Green Mind Theory: How Brain-Body-Behaviour Links into Natural and Social Environments for Healthy Habits. *International Journal of Environmental Research and Public Health*, 14(7), 706. <https://doi.org/10.3390/ijerph14070706>
- Pujol, J., Martínez-Vilavella, G., Macià, D., Fenoll, R., Alvarez-Pedrerol, M., Rivas, I., Fornis, J., Blanco-Hinojo, L., Capellades, J., Querol, X., Deus, J., & Sunyer, J. (2016). Traffic pollution exposure is associated with altered brain connectivity in school children. *NeuroImage*, 129, 175–184.
<https://doi.org/10.1016/j.neuroimage.2016.01.036>
- Puk, T. (2021). Nature-based Regenerative Healing: A case-study of interpersonal ecotherapy. *European Journal of Ecopsychology*, 19–40.
- Pykett, J., Osborne, T., & Resch, B. (2020). From urban stress to neurourbanism: How should we research city well-being?. *Annals of the Association of American Geographers*, 110(6), 1936–1951.
<https://doi.org/10.1080/24694452.2020.1736982>
- Reese, R. F., & Myers, J. E. (2012). EcoWellness: The missing factor in holistic wellness models. *Journal of Counseling and Development*, 90(4), 400–406.
<https://doi.org/10.1002/j.1556-6676.2012.00050.x>
- Reese, R. F., Webster, L. C., & Biles, K. (2018). School counselor roles and opportunities in promoting EcoWellness: Integrating nature connection in K–12 settings. *Professional School Counseling*, 22(1).
<https://doi.org/10.1177/2156759X19839651>
- Rice, J. S. (2012). The neurobiology of people-plant relationships: An evolutionary brain inquiry. *Acta Horticulturae*, 954, 21–28.
<https://doi.org/10.17660/ActaHortic.2012.954.2>
- Richards, D. R., Law, A., Tan, C. S. Y., Shaikh, S. F. E. A., Carrasco, L. R., Jaung, W., & Oh, R. R. Y. (2020). Rapid urbanisation in Singapore causes a shift from local provisioning and regulating to cultural ecosystem services use. *Ecosystem Services*, 46, 101193.
<https://doi.org/10.1016/j.ecoser.2020.101193>

- Robbins, R. N., Scott, T., Joska, J. A., & Gouse, H. (2019). Impact of urbanization on cognitive disorders. *Current Opinion in Psychiatry*, 32(3). <https://doi.org/10.1097/YCO.0000000000000490>
- Roe, J. J., Thompson, C. W., Aspinall, P. A., Brewer, M. J., Duff, E. I., Miller, D., Mitchell, R., & Clow, A. (2013). Green space and stress: evidence from cortisol measures in deprived urban communities. *International Journal of Environmental Research and Public Health*, 10(9), 4086–4103. <https://doi.org/10.3390/ijerph10094086>
- Rosenzweig, M. R., & Bennett, E. L. (1972). Cerebral changes in rats exposed individually to an enriched environment. *Journal of Comparative and Physiological Psychology*, 80(2), 304–313. <https://doi.org/10.1037/h0032978>
- Roszak, T. (2001). *The Voice of the Earth: An Exploration of Ecopsychology*. Red Wheel/Weiser.
- Roszak, T. (2009). *The Making of an Elder Culture: Reflections on the Future of America's Most Audacious Generation*. New Society Publishers.
- Russell, R., Guerry, A. D., Balvanera, P., Gould, R. K., Basurto, X., Chan, K. M. A., Klain, S., Levine, J., & Tam, J. (2013). Humans and nature: How knowing and experiencing nature affect well-being. *Annual Review of Environment and Resources*, 38(1), 473–502. <https://doi.org/10.1146/annurev-environ-012312-110838>
- Selhub, E. M., & Logan, A. C. (2013). *Your Brain On Nature: Become Smarter, Happier, and More Productive, While Protecting Your Brain Health for Life*. Harper Collins.
- Shams, M. (2005). Developmental issues in indigenous psychologies: Sustainability and local knowledge. *Asian Journal of Social Psychology*, 8(1), 39–50. <https://doi.org/10.1111/j.1467-839X.2005.00155.x>
- Shin, L. M., Rauch, S. L., & Pitman, R. K. (2006). Amygdala, medial prefrontal cortex, and hippocampal function in PTSD. *Annals of the New York Academy of Sciences*, 1071, 67–79. <https://doi.org/10.1196/annals.1364.007>
- Song, C., Ikei, H., & Miyazaki, Y. (2016). Physiological Effects of Nature Therapy: A Review of the Research in Japan. *International Journal of Environmental Research and Public Health*, 13(8). <https://doi.org/10.3390/ijerph13080781>
- Srivastava, K. (2009). Urbanization and mental health. *Industrial Psychiatry Journal*, 18(2), 75–76. <https://doi.org/10.4103/0972-6748.64028>
- Stevens, J. S., Jovanovic, T., Fani, N., Ely, T. D., Glover, E. M., Bradley, B., & Ressler, K. J. (2013). Disrupted amygdala-prefrontal functional connectivity in civilian women with posttraumatic stress disorder. *Journal*

- of *Psychiatric Research*, 47(10), 1469–1478.
<https://doi.org/10.1016/j.jpsychires.2013.05.031>
- Summers, J. K., & Vivian, D. N. (2018). Ecotherapy - A Forgotten Ecosystem Service: A Review. *Frontiers in Psychology*, 9, 1389.
<https://doi.org/10.3389/fpsyg.2018.01389>
- Swimme, B. (1994). *The Universe Story: From the Primordial Flaring Forth to the Ecozoic Era--A Celebration of the Unfol.* HarperCollins.
- Tennessen, C. M., & Cimprich, B. (1995). Views to nature: Effects on attention. *Journal of Environmental Psychology*, 15(1), 77–85.
[https://doi.org/10.1016/0272-4944\(95\)90016-0](https://doi.org/10.1016/0272-4944(95)90016-0)
- Tkačik, G., Mora, T., Marre, O., Amodei, D., Palmer, S. E., Berry, M. J., 2nd, & Bialek, W. (2015). Thermodynamics and signatures of criticality in a network of neurons. *Proceedings of the National Academy of Sciences of the United States of America*, 112(37), 11508–11513.
<https://doi.org/10.1073/pnas.1514188112>
- Totton, N. (2011). *Wild Therapy: Undomesticating Inner and Outer Worlds.* PCCS Books.
- Tsunetsugu, Y., Park, B.-J., Ishii, H., Hirano, H., Kagawa, T., & Miyazaki, Y. (2007). Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) in an old-growth broadleaf forest in Yamagata Prefecture, Japan. *Journal of Physiological Anthropology*, 26(2), 135–142.
<https://doi.org/10.2114/jpa2.26.135>
- Turtonen, O., Saarinen, A., Nummenmaa, L., Tuominen, L., Tikka, M., Armio, R.-L., Hautamäki, A., Laurikainen, H., Raitakari, O., Keltikangas-Järvinen, L., & Hietala, J. (2021). Adult Attachment System Links With Brain Mu Opioid Receptor Availability In Vivo. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, 6(3), 360–369.
<https://doi.org/10.1016/j.bpsc.2020.10.013>
- Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, 11(3), 201–230.
[https://doi.org/10.1016/S0272-4944\(05\)80184-7](https://doi.org/10.1016/S0272-4944(05)80184-7)
- Van der Heyden, Y. (2004). *An Exploratory Study of the Use of Metaphor in the Practice of Ecotherapy.* (Doctoral dissertation, University of Stellenbosch)
- Wohlleben, P. (2016). *The Hidden Life of Trees: What They Feel, how They Communicate: Discoveries from a Secret World.* Greystone.