



# Exploring the restorative effects of environments through conditioning

The conditioned restoration theory

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### Abstract

Psychological and physiological restoration have shown to occur in environments containing nature, such as forests, parks and rooms with a window view to nature. The thesis explores the option of explaining restoration through a two-step conditioning model, named the conditioned restoration theory. Conditioned restoration theory suggests that in a two-step process people firstly learn to associate nature with a relaxing emotion, then later retrieves the same emotion when presented with an associated stimulus. Individual steps of the models integrate theory from evaluative conditioning and placebo research, as well as research results from environmental psychology. A study was conducted to further investigate the proposed conditioned restoration framework, exploring whether restoration is affected by experience with nature.

A 2x2 randomly assigned, partially double-blind, experimental design (N = 31) examined the effect of viewing pictures of nature and urban environments on the Attention Network Task, digit span backwards, mood, and investigate the moderation effect of previous experience with nature. The Experience with Nature in Child and Adulthood inventory was developed to assess earlier and current experience with nature.

Results suggest that viewing pictures of nature significantly improves the executive control sub score of attention network task, reduce arousal, and partial signs of an improved digit span backwards scores. Regression analysis suggest that improvement in executive control is negatively related to the Love and Care for Nature scale, arousal in nature as a child, and heart rate variability, as well as positively related to current amount of interaction with nature. Regression analysis should be interpreted as suggestive and need replication to validate results.

As predicted by conditioned restoration theory, viewing pictures of nature reduce arousal, and arousal in nature as a child predicts increase restoration. This suggest low arousal has been conditioned to nature in childhood, affecting restoration.

Coupled with previous research, the thesis suggests conditioned restoration theory as a valid framework for the restorative effect of environments, which could prove to be a major contribution to environmental psychology.

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**Abbreviation directory**

ANT	=	Attention Network Task
ART	=	Attention Restoration Theory
CR	=	Conditioned Response
CRT	=	Conditioned Restoration Theory
CS	=	Conditioned Stimulus
DV	=	Dependent Variable
ENCA	=	Experience with Nature in Child and Adulthood
HRV	=	Heart Rate Variability
IV	=	Independent variable
LCN	=	Love and Care for Nature
PANAS	=	Positive and Negative Affect Schedule
RRS	=	Ruminative Responses Scale
SAM	=	Self Assessment Manikin
SRT	=	Stress reduction theory
UCR	=	Unconditioned Response
UCS	=	Unconditioned Stimulus

## Introduction

Environmental psychology is the study of how people perceive and respond to the physical environment. The research often differentiates between the effect of humans on the environment and environmental effects on humans. Environmental psychology began to emerge as a self-identified sub discipline in the 1950s (Clayton & Saunders, 2012). Key topics at the time included perception of the environment, social uses of space, risk perception, and attributes of built environment. The effects of the environment on human perception, cognition, affect and behavior have recently gained increasing attention. Especially the subject of “restorative environments” is flourishing, netting a 657% increase in articles containing the phrase in the two previous decades (296 to 2240, Google Scholar).

Going for a walk through a park after a stressful day at work qualifies as a type of restoration, where the park is the restorative environment. Research shows that going through the park is more restorative than going through urban settings, and research on restorative environments investigate aspects related to this.

Restorative mostly translates to psychological and physiological advantages of being exposed to an environment, often nature, this includes walking in, having a window view of or even just viewing pictures of the environment. The effects of environmental restoration have primarily been shown to affect stress and directed attention.

The restorative environments field is currently dominated by three leading theories as of how nature have these positive effects. The leading theory, attention restoration theory (ART; Kaplan and Kaplan, 1989), relies on attention, that nature is a “soft fascination”. Perceiving nature does not require attention, allowing the attentional resource to rest and recover itself, increasing, and resulting in various cognitive benefits. As an alternative to ART, Ulrich’s (1983) stress reduction theory (SRT) suggest instead of restored attention, stress reduction is key, nature has an inherent relaxing effect on humans, which leads to restoration. Both these theories rely on an innate evolutionary approach as to why. The third more recent theory concerns fluency and fractals, explaining the preference and restorative powers of nature through its ease of perception and fractal patterns, proposed by Joye & van den Berg (2011), but more specified by Hagerhall,

Purcell, and Taylor (2004). Although not officially presenting the same theory, they are very similar and the thesis will focus on the more formal of the both, presented by Hagerhall and colleagues (2004). The thesis will summarize central aspects of the theories, outline some central issues and suggest a fourth approach.

### **Attention restoration theory**

Based on citations, the attention restoration theory (Kaplan & Kaplan, 1989) is arguably the most employed theory, being cited three times more often than SRT and perceptual fluency. This is perhaps due to its more direct approach to describing what type of environment causes restoration, making it more applicable to practical settings, such as city planning and gardening.

Rachel and Stephen Kaplan began developing the ART in the 1970's (Staats, 2012) where they asked participants who went on week long hiking trips to keep a diary of their experiences. This data laid the foundation for the theory. The theory can be divided into three parts, cognitive mechanism for the restoration, what type of environment facilitates restoration, and the origin of this mechanism. The cognitive mechanism for restoration relies on the notion that attention has two modes, voluntary and directed, or involuntary and spontaneous. Directed attention focuses on a task while consciously ignoring other stimulus. Involuntary attention perceives whatever stimulus is presented, without conscious "guiding" of attention. ART proposes that directed attention is a limited resource, closely similar to physical strength, which needs to rest in order to replenish.

Kaplan and Kaplan (1989) have however not focused on the cognitive mechanism concerning attention restoration in recent times, but rather on what type of environments that facilitates restoration. ART (Kaplan & Kaplan, 1989) list four qualities of nature that facilitates restoration. Firstly, the environment needs to give a sense of *being away*, the person needs to feel distanced from their daily chores and demands that tolls their directed attention. The environment needs to be *fascinating* so that the involuntary attention is grasped, resting the directed attention. The feeling of *extent*, when the environment is perceived as structured, orderly, and immersive. Finally, *compatibility* is needed, a correspondence between what one wants to do and what the environment allows or necessitates. Fascination is believed to be the most important one, being the primary



mechanism behind resting attention. The three others, being away, extent, and compatibility enhances or prolongs the fascination.

**Limitations.** In its core, ART explains the increase in attentional test scores, but falls short in explaining some of the broader effects of nature. Increased hospital recovery time (Ulrich, 1986), reduced blood pressure, anger and aggressiveness (Hartig, Evans, Jamner, Davis, & Gärling, 2002) and sympathetic activation measured through skin conductance level (Alvarsson, Wiens, Nilsson, 2010), cannot be explained by restored directed attention. Restored attentional recourses should not reduce the need for analgesics and other physiological effects. And while a direct restoration of attention falls short in explaining these physiological effects, stress and emotional effects, as suggested by SRT, can explain attention restoration. Darke (1988) showed that high anxiety subjects scored significantly lower on a digit span test than low anxiety subjects. Tang and coworkers (2007) showed increased scores on the executive control aspect of the Attention Network Test (ANT), a score frequently used in restorative psychology, following a short five-day meditation train program, focusing on relaxation. It is strong evidence that stress reduction has the same effects as attention restoration, or that indeed stress reduction can cause attention restoration.

It could be argued that ART operates on a different cognitive mechanism than stress, tapping into different cognitive mechanism. Stress could affect attention restoring, but in addition to this nature also directly affects attention restoration. But this could be argued to be a weak point. If stress already accounts for the changes in restored attention, the need for a separate theory relying on a rather new cognitive mechanism to account for the restored attention already accounted for is significantly reduced. When a phenomenon is already explained through established theory, there is no need for additional more complex theory to explain a smaller portion of the findings. It is likely that stress reduction accounts for the full effect of attention restoration.

Like stress reduction theory, ART relies on evolution to account for the “why” of this effect, also implying that this is an innate cognitive mechanism shared by all humans. A recurring issue with evolution to explain why a feature exists, is that it can also be used to explain the opposite. For example, it's been shown that water often have restorative properties (Wheeler, White, Stahl-Timmins, & Depledge, 2012). This could be because in an evolutionary context, being close to water is advantageously, as it is essential to

survival. People that enjoyed residing near water often did so and therefore had more readily access to water, an advantageous evolutionary trait. But the direct opposite could also be explained in an evolutionary context in the sense that one should be on high alert because water is a natural destination for predators. Other examples can be shown; nature is relaxing because it is our natural environment; built environment is relaxing because it is safer. Almost every trait is evolutionarily advantageously in some way regardless as to what findings is presented, presenting an evolutionary setting where this is advantageous is extremely easy.

A good summary of multiple issues regarding an evolutionary explanation can be found in Joye and van den Berg (2011), which the thesis will not focus on. Joye and van den Berg (2011) writes “A detailed analysis of SRT's psycho-evolutionary framework shows that neither current empirical evidence nor conceptual arguments provide any strong support for the hypothesis of restorative responses to nature as an ancient evolved adaptive trait.” (p. 1). Some arguments include why the mechanisms is fast, as this would have little advantage. Since humans evolved amongst vegetation, we would naturally already reside there, strongly reducing the need for extra motivation to reside there. The idea of cognitive “adaptive lag” have also been a controversial topic and not yet confirmed.

In summary there seem to be relevant issues especially concerning the evolutionary explanation as to how nature is restorative. Stress or emotional change could be a more likely explanation for the increase in attentional resources than a direct nature - attention causal connection as ART suggest. This “why” and “how” of ART explanatory models falls short and could be said to not be well founded in scientific theory.

### **Ulrich's Psycho-Evolutionary Theory of Stress Reduction**

Stress reduction theory (SRT; Ulrich, 1983) suggests that stress is the main component of the benefits of nature. The theory states that through a primarily evolutionary innate process, the appreciation of a natural settings such as trees, mountains, water, and plains with the absence of a focal point, a degree of depth in the scene, surface texture, and the absence of a threat, affects stress levels. Research shows a connection towards physiological stress reduction, such as higher parasympathetic nervous system activation and relaxation in nature compared to urban environments (Ulrich, Dimberg, &

Driver, 1990). SRT relies heavily on physiological studies, which is advantageous, as it can identify consequences nature that may be outside the conscious awareness of participants and hence may not be identified by verbal methods.

In explaining “why” nature has these restorative properties, Ulrich (1983) also relies on an evolutionary explanation. It has been beneficial for humans to be attracted to landscapes that is both fertile, promise food, water and absence of danger. Persons that were attracted to these environment, chose to stay in them, and had an evolutionary advantage over people that did not.

**Limitations.** Because the SRT relies on an evolutionary basis of stress reduction when humans are in a natural setting, it has similar issues to ART. It falls short in explaining similar or identical effects when nature is absent. Studies show that that visitors experience the same restoration in a museum, absent nature (Kaplan, Bardwell, & Slakter, 1993). The same restoration is shown when redecorating a hospital room to resemble home environments (Ohta et al., 2007). Several non-nature environments have shown to facilitate restoration (Devlin & Arneill, 2003) If other types of environment have the same effect, it is likely that they rely on the same cognitive mechanism.

An evolutionary explanation presupposes that earlier experience with nature should not have any major influence. But differences in restoration when exposed to nature have been shown. Children who work with their parents in nature experience significantly less restoration in nature (Collado, Staats, & Sorrel, 2016), and people that have a working relation with nature reported significantly lower restoration (von Lindern, Bauer, Frick, Hunziker, & Hartig, 2013).

These arguments do however have a catch. One cannot conclude from identical outcomes on identical causes. Nature could work through one cognitive mechanism, and artificial restorative environments such as museums via another. However, from a reductionist point of view the observed and measured restorative effects should be attempted to be explained by the least amount of testable predictors and under avoidance of presumptions that cannot be refuted. A similar argument could be raised for the individual. It is possible that an evolutionary trait lies in the background, but is obscured by experience, such as work in nature. It is nonetheless highly suggestive, and a model concerning the cognitive mechanism of restorative environments would benefit from including all types of restorative environments.

## Fluency and Fractals

The most recent contribution to restoration theories is originally brought to attention by Joye and van den Berg (2011). This theory differs in its explanatory approach and does not rely on evolutionary explanations.

The core of perceptual fluency is that nature is easier to perceive and process than other stimuli based on its fractal pattern. A fractal is a rough or fragmented geometric shape of which the parts are each approximately reduced-size copies of the whole (Joye & van den Berg, 2012) A fractal pattern is something that is made up of itself, with the most straightforward examples is the broccoli, where its smaller branches is nearly identical a scaled down version of the whole vegetable. A more readily example is also a tree, where a small branch often represents the bigger branch, which again represents the whole tree. This pattern makes it easier to perceive and process, making way for cognitive restoration.

**Limitations.** Two limitations are apparent regarding perceptual fluency. Firstly, a central study to the theory (Hagerhall, Purcell, & Taylor, 2004) could be said to apply some controversial methods where it first receives no significant results, then removes all pictures containing water or hills, which only then provided significant data. This implies the theory does not apply to environments containing water or hills. Because both water and hills are a large part of nature and restorative environments, this could be said to be a major weak point. The theory also relies on vision, but stress recovery has been found using only nature sounds (Alvarsson et al., 2010). The reliance on vision also implies that visually impaired individuals does not experience restoration in nature, which no evidence suggest.

Secondly it is hard to avoid the issue of causality regarding the findings. Most nature is fractal because developing this is more accessible. If it were that people like nature for other reasons, conditional associative learning could apply preference to fractal patterns. One could easily develop a preference for fractal patterns because one likes nature. Because close to all nature is fractal, and persons have a tendency to like nature, there is bound to be a strong correlation between nature and preference. The more nature in a setting, the more preference, and fractal patterns. If there was no causal connection between fractal patterns and preference, studies would very likely still show correlations

between fractal patterns and preference, the same results which are used to support the theory. This question of causation could be said to be a shortcoming.

### **The Conditioned Restoration Theory**

The thesis proposes that there is a better cognitive explanation for the observed effects of nature than suggested by the three leading theories. The author argues that the full effect of nature and other restorative stimuli can be accounted for in a two-step model relying on conditioning and associative learning. The first step includes associating nature with a relaxing emotion, and the second step is later retrieving the same emotion when presented with an associated stimulus, shown in figure 1. In a nature - restoration setting, on which the experimental work in this thesis focuses, one first learns to associate nature with something relaxing, then later on when presented with nature, through conditioning triggers relaxation. In a classical condition framework, an unconditioned stimulus (UCS): nature, is paired with the unconditioned response (UCR): low arousal experiences. After conditioning the conditioned stimulus (CS) nature is paired with the conditioned response (CR): arousal reduction. After this nature triggers low arousal. The author argues there is good support for both processes, which combined explains most research on restorative environments.



*Figure 1:* A short model of the CRT.

The following section will explain the Conditioned Restoration Theory (CRT) thoroughly, its similarities and differences with ART and SRT, strength and weaknesses. Thereafter evidence supporting the theory will be reviewed.

### **Conditioning of emotion to environment**

This first step in CRT is somewhat intuitive, repeatedly experience an emotion in an environment, and you will associate the environment with the emotion. This relies on two-steps. Firstly, the emergence of a relaxing or stress reducing feeling when in nature is required. Staats (2012) suggests that research on the social context of restorative environments have been ignored, in which the author agrees. The role of conditioning, environment, and health effects have been lightly explored (Sütterlin, Egner, Lugo, & Wojniusz, 2015) The author suggest that evidence for relaxation in nature based on its social context is strong, as it is draws from emotional and social research. Relying on the context of nature and not nature itself, also makes CRT generalizable to other environments, which could be argued to been an issue of other natural restorative research, as it did not account for restoration in other environments.

It should be noted that how the emotion occurs is not central to CRT. The important part is only that an relaxing emotion occur, not how. This is because regardless of how the emotion occur, CRT can still exist as a framework. The author especially regards ART's (Kaplan & Kaplan, 1989) being away, fascinating, extent, and compatibility facets to be an important correlate to when relaxation occurs. The thesis will nonetheless focus on somewhat simpler grounds for a preference for nature than previously proposed mechanisms.

The second step conditions the emotion relaxation to nature. Considered conditioned response is one of the oldest findings in psychology, conditioning an emotion or state of mind to a stimulus is surprisingly meagrely explored (Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). The closest one comes to an established field of stimulus-emotion conditioning, is the field of evaluative conditioning, in which CRT will apply in this second step.

**Emergence of relaxing feeling.** The thesis will present several nonexclusive approaches as to how being exposed to nature directly could give a relaxing feeling. It should be noted that this is not aimed at indirect nature, such as pictures of nature or plants at the office, which will be covered later in the thesis (p. 20).

It is believed that the primary reason for persons to relax in nature is based on the setting in which the vast majority of modern society interact with nature; as a leisure activity. Forests and mountains is primarily used for activities such as hiking, going for a walk, exercise, picnics, and general recreational activities. These are activities that are relaxing in themselves. Only a fraction of the population relates nature to stressful activities, including but not limited to lumberjacks, fishermen and soldiers having fought in natural environments.

The secondary reason thought to give relaxation in nature relies on Kaplan and Kaplan's (1989) person-environment factor of *being away*. Nature is often an environment removed from daily chores, where there is little that "needs" to be done. Wohlwill (1983) points out the lack of social feedback in nature is key. Although social feedback can be positive or negative, it mostly brings arousal, while a lack of social feedback could be said to generally lower arousal.

Lastly it is believed that socially induced expectancy also affects the emergence of relaxation in nature. This argument naturally suffers from causation issues, as a social expectancy would be unlikely to occur if nature was not a relaxing environment in the first place. But it is nonetheless argued that this strengthens the effect, as expecting something to have an effect affects the activity itself (Bandura & Walters, 1963). It should be noted that non-social expectancy and conditioning effects is not included here, as a personal experience is required for this to occur, and this step is about the *emergence* of an emotion, not later occurrences in the same environment.

In sum, interacting with direct nature, such as forests, parks, and mountains, produces a positive and relaxing emotion primarily through the kind of activities that are common in nature and are detachment from regular life and social feedback. Regularly experiencing the same emotion in an environment leads to conditioning of environment and emotion.

**Conditioning of emotion and environment.** Classical conditioning is one of the oldest research traditions in psychology (Martin, Carlson, & Buskist, 2012). It refers to a learning procedure where a stimulus is paired with response and behavior is modified thereafter. Classical conditioning relies on mental association, which is the basis for many similar cognitive mechanisms. The pairing of a relaxing feeling and nature could be

explained through classical conditioning, but is arguably better explained through its sister mechanism, evaluative conditioning.

Evaluative conditioning has many similarities with classical conditioning, but it differentiates itself in conditioning of emotion, mostly valence, how much a person likes something, and not behavior (De Houwer, Thomas, & Baeyens, 2001). In evaluative conditioning research, it is often attempted to influence a person's valence of things through association, for example faces, tea or textiles. The classic experiment in evaluative conditioning presents a high valence face with a neutral valence face. After several pairings, this increases the valence of the neutral face. Similar effects are achieved with pleasant smells. If a smell is occurring relatively close to the presentation of a face, the face increases in valence (De Houwer et al., 2001). The strongest effects is found in food. If a beverage is added a foul taste such as soap, the person will dislike the original taste of the beverage even when soap is not present. This knowledge is often employed in clinical settings, where most cancer patient will develop a dislike for the food they eat, as it is linked with poor health due to radiation and/ or chemotherapy (Bernstein & Webster, 1980). Patients are therefore given food with odd spices, so that they will not dislike normal food post-treatment.

Evaluative conditioning differs from classical conditioning in several ways. Most important to the thesis and CRT is its extreme resistance to extinction, relative to classical conditioning (De Houwer et al., 2001). In Pavlov's classical experiment, once the bell has been conditioned with food, the dog salivated when the bell rang. But when the bell started to ring without food for several trials, the dog stopped salivating (Pavlov, in Martin et al., 2012). This extinction effect is significantly reduced in evaluative conditioning (Hofmann et al., 2010). Once a stimulus has been associated with negative valence, the stimulus will have a low valence regardless if pairing stops. It is also resistant to counterconditioning. Once a conditioning has been achieved, attempting to condition contradicting valence is difficult (Hofmann et al., 2010).

Several other aspects of evaluative conditioning are important. Evaluative conditioning is relatively unaffected by statistical contingency (Baeyens, Hermans, & Eelen, 1993). This means that even though the unconditioned stimulus (US) and/ or the conditioned stimulus (CS) are presented independently several times, this does not significantly affect the conditioned evaluation of the CS. It should be noted that there



probably is a small effect present, but Baeyens and colleague's (1993) studies lack in sample size and did not show this (according to De Houwer et al., 2001). Evaluative conditioning is unaffected by contingency awareness, whether the participant is aware of the experiments purpose and hypothesis. Lastly it is unaffected by modulation procedures. One can dislike a face for pairing with other faces, smells or electrical shock; it does not matter in which medium the condition is applied (Hofmann et al., 2010).

Although valence is the main focus of evaluative conditioning, other emotions have shown to follow the same mechanism, although this has received limited research (J. De Houwer, personal communication, 14. January, 2016). Arousal has been shown to be conditioned in the same manner as valence (Gawronski & Mitchell, 2014). Although not the main purpose of the study, data revealed that a high-arousal US paired with a neutral CS significantly increased the arousal of the CS. Although the same was not found for low arousal, it should be noted that the baseline arousal for unpaired CS were initially low. So it is likely that a conditioning was occurring in the low-arousal condition as well, but the initial arousal for the CS was already low, so no difference was observed.

In summary, there is strong evidence for conditioning of emotion to stimulus. Both valence and arousal has been transferred, and it is likely that this happens for other emotions as well. Based on the presented theory, in a CRT framework it is hypothesized that high valence and low arousal is conditioned on to the environment and associated stimuli. When participating in multiple relaxing/ low arousal and pleasant/ high valence activities in nature, as discussed in the previous section (p. 14), these emotions are conditioned with nature. Even if exposed to some negative experiences in nature, this does not affect the conditioning, as evaluative conditioning is extremely resistant to nature. The person does not need to be aware of the connection, as contingency awareness does not matter. Lastly modulation is no issue, conditioning occur even if the two stimuli are unrelated, for example trees and lack of social feedback.

It is stressed that the CRT framework is not exclusive to the nature environment, but can be employed in all environments, although it focuses on nature and restoration. An example regarding other environments could be to associate your office with stress, if one experience multiple stressful events there. Or associate a cabin with relaxation.

### **Reemergence of emotion when exposed to associated environmental**

The previous section propose how emotions can be conditioned to an environment. Specifically how a relaxing feeling can be conditioned to nature. The remaining step is to explain how nature gives rise to a relaxing feeling or comfort, as well as explain how this can increase or restore cognitive test scores (Berman, Jonides, Kaplan, 2008) and give physical benefits such as decreased post-surgery recovery time (Ulrich, 1984). The thesis will first propose a mechanism for how stress is removed in direct nature (p. 18), then indirect nature (p. 20).

**Influence of direct nature.** By ‘direct nature’ the thesis refers to environments such as forests, large parks and mountains, environments which are fully dominated by nature. This is excluding environments such as rooms with pictures of nature or office plants, which is referred to as ‘indirect nature’. We hypothesize that conditioning is still the primary mechanism in this process. The thesis brings in placebo response, the change in an individual caused by placebo manipulations (Hoffman, Harrington, & Fields, 2005). Placebo response can be defined as change in symptoms occurring during a clinical trial in patients randomized to receive a placebo (Rutherford & Roose, 2013). A large portion of placebo research is mostly applied in clinical settings, and the vast majority of articles concerns analgesics, pain medication. Nonetheless, the cognitive and physiological mechanisms used to explain placebo is well supported and fits the CRT framework very well. It can even be argued that a reduction in pain and reduction in stress is far from unrelated domains. In both domains, contextual influence on subjective affective and cognitive experience is key. The thesis will go through the two psychological mechanisms primarily used to explain placebo; the classical conditioning model and conscious expectancy (Hoffman et al., 2005).

***The classical conditioning model.*** The classical condition model relies as the names suggest on classical conditioning, as originally researched by Pavlov’s classical experiments (Martin et al., 2012). Advocates of the classical conditioning model claim that placebo responses arise after an individual is exposed to repeated pairing of sensory cues such as environments and effective treatment (Hoffman et al., 2005). The person does not need to be consciously aware of the conditioning occurring. The most straightforward

example is a patient that is given analgesics, which reduces pain, after multiple treatments the patient associates pain reduction with the analgesic, which in turn increases the effectiveness of the drug (Benedetti, 2006). In a nature - restoration setting relevant to the model, a person experiences an environment, forest, and a relaxation on multiple occasions. A conditioning is formed and the next time the person goes to a forest; he experiences relaxation simply because he is in nature.

Although, the model is primarily employed in analgesics, there are little reason to believe it should be employed as a model domain-specific to analgesics. Classical condition has and is being employed on all types of domains and have shown its effectiveness in both humans and animals alike across virtually every medium (Martin et al., 2012).

***Conscious expectancy.*** Conscious expectancy relies on conscious anticipation of improvement to occur. The person expects an automatic reaction to a particular situational cue, which in turn activates the anticipated response (Hoffman et al., 2005). The most commonly used example is a nurse which gives a patient an analgesic, orally stating “this will reduce pain”, the patient expects pain to be reduced and pain is further reduced as a result of this (Benedetti, 2006). In a CRT setting, a stressed person could go into nature, expecting it to be relaxing and nature will be (more) relaxing as a result of this expectancy. It should be noted that mechanism requires the subject to be aware of the process (Price, Finniss, & Benedetti, 2008). If the subject is not consciously not aware of what to expect or when to expect it, expectancy cannot occur. This is contrary to the classical condition model, which does not require consciousness (Price et al., 2008).

***Placebo and CRT.*** Although the classical conditioning model and conscious expectancy are subject to some rivalry, the two are far from mutually exclusive and it is generally accepted that both are valid (Hoffman et al., 2005). Even though expectancy has on average generated larger effect sizes than conditioning, it could be said that the first cannot occur without the latter, *if* one considers the expected result as an UCS and the response as the UCR. In relation to nature and CRT, it is reasonable to assume both are in work at the same time. Conditioning creates a feeling of relaxation because this has been previously conditioned through evaluative conditioning, while expectancy creates relaxation because most people expects to experience this when going in nature.

It should be again noted that the CRT does not specify environment or emotion. If a person has experienced multiple stressful experiences in nature, such as soldiers with combat experiences in forests, that feeling could also be conditioned and expected. The thesis will nonetheless focus on restoration and/ or stress reduction in nature. The next section will explain how advantages of indirect nature can be explained by CRT.

### **Influence of indirect nature**

By “indirect nature” the thesis refers to environments which have elements of nature, such as rooms with a window view of nature, plants, pictures of nature or even computer backgrounds with nature. This is excluding environments such as forests, mountains or beaches. Similarly to the explanation for indirect nature, it is believed that the explanation for the cognitive and physiological advantages of nature can be found in placebo literature, as explored in Sütterlin and colleagues (2015).

The explanation once again relies on conditioning and expectancy in demonstrating the advantages of indirect nature, but classical conditioning plays a relatively bigger role regarding indirect nature, and expectancy plays a somewhat smaller part. It is believed that situational cues from aspects of nature is enough to trigger the conditioned response of direct nature. The perception of indirect nature, for example a picture, triggers emotions similarly to those already associated with direct nature. Expectancy could play a lesser role as consciously expecting to be restored by for example a window view to nature seems less intuitive, somewhat illustrated by the fact that Ulrich’s (1984) experiment was so groundbreaking it was accepted in the prestigious journal science.

Emotional activation caused by stimuli vaguely related to the original stimulus is found in cases of post-traumatic stress disorder (Nolen-Hoeksema, 2011). In soldiers, loud noises and bangs can cause strong emotional flashbacks to war. Based on personal experience, it is well-known that viewing pictures of those we love induce very different emotions than viewing pictures of our boss at work. Indirect stimulus replicating emotions associated with the original stimulus.

It is not believed that indirect nature has generated its own conditioned response. This is because indirect nature is often situated at already stressful environments such as work, and indirect nature in an environment vary too much to form a stable conditioned response. For example, one is often exposed to indirect nature both in many urban areas,

your office, at home, in meetings, in your car and through windows. It is believed that these environments, all containing indirect nature, is paired with a far too wide spectrum of emotions to form a solid conditioned emotional response. The primary effect of indirect nature is thought to occur to association with the original stimulus, for example forests.

### **Similarities and differences to established theory**

CRT aims to primarily investigate the cognitive mechanisms of how nature causes restoration. In doing this, it relies on Ulrich's (1983) suggestions that stress is the primary cause of the benefits of nature, but does not agree with the evolutionary explanation. Concerning ART, it does not agree with attentional restoration as a direct effect, but an effect mediated through stress reduction. CRT does however agree that the factors of being away, compatibility, fascination, and compatibility correlate strongly to actual restoration, and could be an ideal psychometric concerning the phenomenon. This is because these factors strongly correlate to how emotion is associated with nature. Especially being away and fascination should predict a high valence low arousal connection, which facilitate restoration both according to ART and CRT.

### **Summary**

In summary, CRT offers a framework based on conditioning research for the restorative effects of nature. Most of the individual links of CRT are established fields in other branches of psychology, primarily within evaluative conditioning, placebo research, and classical conditioning. In modern society nature is used as a leisure environment, the positive experiences with and in nature are conditioned into nature itself, which gives emergence to the same feelings when exposed to nature, as well as items that represents nature.

### **Restoration and stress**

Not a direct part of the CRT, the thesis will present likely connections for the effects of low stress and physical and mental recovery. The most well-known study showing this phenomenon is Ulrichs (1984) study regarding hospital recovery time. Results showed that patients who had a window view to nature had shorter postoperative

stays at the hospital, received fewer negative evaluative comments from nurses and took less potent analgesics.

CRT argues that the effects of a window view, indirect nature, relaxes the patient and reduces stress, via the two-step conditional model presented. A likely major contributor to physical advantages is the activation of the parasympathetic nervous system, as its activation has been shown to engage bodily restorative functions (Kalat, 2016).

**The parasympathetic nervous system.** The parasympathetic nervous system is part of the autonomic nervous system, which is again part of the peripheral nervous system (Kalat, 2016). The autonomic nervous system consists of neurons that receive information from and send commands to the body's organs. It is divided into the sympathetic and parasympathetic nervous system. The parasympathetic nervous system facilitates vegetative, non-emergency responses. It affects bodily functions such as decrease heart rate, increases digestive activities, and in general conserve activity (Kalat, 2016). Most over-the-counter cold remedies exert most of their effect by boosting the activity of the parasympathetic nervous system. If perception of nature does induce relaxation, this would increase parasympathetic nervous system activity, which again could strongly increase physical and also mental restoration.

**Heart rate variability.** Central to parasympathetic nervous system activity is heart rate variability (HRV). HRV is the variability in time interval between heartbeats. If one person's two heartbeats are 100ms and 105ms apart, the person's HRV for those heartbeats are 5. Without going into detail of why, as it is not the thesis purpose, vagally mediated HRV, which can be extracted from HRV, are one of the best measurements for parasympathetic nervous system activity (Task force, 1996). A baseline HRV, which is commonly measured in a five-minute time period where the subject is asked to relax and do nothing, is an indicator of potential parasympathetic nervous system activity (Task force, 1996).

Because HRV can be used as a marker for parasympathetic nervous system activity, it could serve as a useful indicator for restoration in nature on two instances. Firstly it is believed that the baseline HRV of participants will correspond with the restorative effects of nature, as it represents how much a person *can* recover. Secondly it is believed that HRV during exposure to nature monitors the magnitude of the recovering process.

**Cognitive benefits.** In a CRT framework the cognitive benefits of being exposed to nature relies similarly to SRT (Ulrich, 1983) on the removal of stress. The thesis will briefly present some studies showing stress to have a negative influence on cognitive test scores.

Several studies show a negative correlation between stress and cognitive test scores. High anxiety subjects score significantly lower on a digit span test than low anxiety subjects (Darke, 1988). Attention is reduced in exam periods compared to non-exam periods, although short term memory is increased (Vedhara, Hyde, Gilchrist, Tytherleigh, & Plummer, 2000). Finally Sanger, Bechtold, Schoofs, Blaszkewicz, & Wascher, (2014) showed a significant increase in both error rates and response times on the socially evaluated cold pressor test, especially on tasks dependant top-down processing following a stressor.

Berman and colleagues (2008) argue that nature only the executive control aspect of the ANT because in an ART perspective, nature only affects attention. The thesis however argue that this argument is flawed because as far as the author is aware no experimental study has ever been able to affect the two remaining subscores, alerting and orienting. This could imply that alerting and orienting are extremely stable and very hard to affect. Studies demonstrating the difficulties in altering anything but executive control will be presented shortly.

There is no shortage of studies or theories regarding stress and cognitive performance. The author judge it very likely that stress and reduction in stress is the core mechanism behind the differences in test scores observed in most restorative nature studies as studies show a negative correlation between stress and test scores. It is this mechanism CRT also relies on to explain the same findings.

### **Empirical support**

The thesis will present several studies regarding interaction with nature and/ or restoration. Firstly it will explain a classical study with a CRT framework, and present data from lesser known studies in which the author believe CRT explains the findings often better than established theories.

**View through a window may influence recovery from surgery.** Roger S. Ulrich (1984) presented one of the most influential studies in environmental psychology when he showed the physical restorative benefits of simply having a window view to nature. Patients with a window view to nature “had shorter postoperative hospital stays, had fewer negative evaluative comments from nurses, took fewer moderate and strong analgesic doses, and had slightly lower scores for minor postsurgical complications” (Ulrich, 1984, p. 2).

CRT proposes these findings in a straightforward way. Nature had from early childhood been conditioned to be relaxing. This relaxation is induced when exposed to indirect nature in the hospital, increasing parasympathetic nervous system activation which speeds recovery.

**Variations in environment and participants.** CRT hypothesize that all environments could theoretically give the same effect as nature, and that there are variations amongst individuals based on previous interactions with the environment.

**Effects of redecoration of a hospital isolation room with natural materials on stress levels of denizens in cold season.** Ohta and colleagues (2008) investigated the effect of redecorating an isolation room in a hospital with traditional homey decorations<sup>1</sup>. Although it can be criticised for a relatively small sample ( $n = 7$ ), the study showed that participants that stayed in the redecorated room felt more thermally comfortable and more importantly, plasma cortisol levels, a common indicator of stress, decreased significantly. Although minimal for participants with already low levels of cortisol, the effect was bigger for participants with high levels

Although Ohta et al. (2008) employs a different sample and operationalization of stress than Ulrich (1984), the results are similar. An implementation of environment that is associated with relaxing conditions produced a reduction in stress in a hospital. In a CRT framework, the conditioned relaxation from the traditional environment induced a relaxing feeling in the patient, and reduced stress, which again reduced plasma cortisol levels. This is further supported by the fact that participants that were already relaxed showed no improvement, implying that the stress level trends *towards* a specific level, which likely is the conditioned stress level of home.

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<sup>1</sup> The rooms were decorated with wood paneling and Japanese paper. Since the study was conducted in Japan, this is interpreted as traditional homey decorations, as done by Sütterlin and colleagues (2015).



It should be specified that similar results are no guarantee for the same underlying mechanism. The reduction in stress could be mediated through different means, and Ulrich (1984) did not directly measure stress, he only theorized that it was the cause. The findings are nonetheless highly suggestive, and in combination with other studies the thesis hopes to lay a strong foundation for CRT.

**The Museum as a Restorative Environment.** On the topic of other environments achieving the same results as nature, Kaplan, Bardwell and Slakter (1993) showed that museum visitors also received some levels of cognitive restoration. Museums are experience wise perhaps the closest thing to nature one can achieve, with an environment that is strongly encouraging relaxing activities.

A problem with investigating CRT is the lack of control groups. Finding participants that have not conditioned nature in some way would be difficult. In the museum setting however, this is highly possible. In fact, Kaplan, Bardwell and Slakter (1993) found that “museum-novices” did not experience much restoration. Although explaining these findings through other means, CRT suggest that they do not receive the same amount of restoration simply because the museum setting has not been conditioned in these participants. With repeated visits to the museum, this relaxing feeling is conditioned and restoration is more reliably achieved.

The study has some weaknesses. “Cognitive restoration” in this study does not refer to an actual restoration, but rather a 13 items questionnaire items reflecting the four components of ART. As previously mentioned, the author is supportive of these components correlation with restoration, but it should be noted that the restorative value is not completely valid in this study.

**Stress Recovery during Exposure to Nature Sound and Environmental Noise.** CRT claim that restoration does not need to be triggered visually. Any associated stimulus can trigger the emotion conditioned to an environment. Alvarsson and colleagues (2010) showed that after exposure to a stressful mental arithmetic task, nature sounds compared to a high noise, low noise or ambient sounds reduced Skin Conductance Level (SCL), which is interpreted as sympathetic nervous system activation, and again stress.

Data suggest that nature can induce restoration from sound alone. In a CRT framework, the sound of nature retrieves the associated emotion, relaxation, which reduces stress and SCL. These data could be said to be particularly problematic to a visually

focused theory such as the perceptual fluency account, as restoration occurs in the absence of visual stimuli.

**Helping out on the land: Effects of children's role in agriculture on reported psychological restoration.** As suggested by CRT and supported by Kaplan and colleagues (1993) study concerning museums, not all individuals are restored by nature. Individuals which does not associate nature with relaxation and leisure activities etc. will receive little to no restoration. This is also suggested in a study conducted by Collado, Staats, and Sorrel (2016) showing that children that have a work relationship with nature report less restoration when spending free time in nature than children that do not work in nature (Cohen's  $d = -0.65$ ). This was mediated by a lower sense of being physically away (Cohen's  $d = -0.45$ ), as well as psychologically away (Cohen's  $d = -0.39$ ).

As mentioned, the author considers the four ART dimensions good indicators as to how strong restoration a person experience in nature, it mostly disagree on the directed attention and evolutionary explanations as to how. These findings fit a CRT framework perfectly, children who have worked in agricultural environments does not associate this environment with leisure or relaxing activities, which conditions the environment differently than in the control group, reducing restoration.

This study also somewhat suffers from non-objective measures of restoration. The measure used was four inventory items meant to represent restoration. Although it is understandable that inventory items allow for a much larger sample size as well as far easier testing, it is a somewhat recurring issue in environmental psychology that items are used in place of actual restoration, for example an ANT pre-post test.

**Occupational engagement as a constraint on restoration during leisure time in forest settings.** Similar results are shown in a study conducted by Lindern and colleagues (2013) which investigated reported restoration and occupational engagement. Participants who had a profession related to forests, experienced less restoration than people than participants that did not. This fits a CRT framework, people with working experience with nature conditions tend to be associated with less relaxation than people without working experience with nature.

Although published in *Landscape and Urban Planning*, the study can be criticised for its somewhat misleading title and abstract regarding effect size. The reported correlation between profession and reported restoration is only  $r = .07$ . Since the first is

used to explain the latter, explained variance  $r^2$  are somewhat more relevant, which calculates to  $r^2 = 0.0049$ , so profession explain 0.5% of the variance in reported restoration. It is likely the studies high power ( $N = 1678$ ) is the reason for its achieved statistical significance. Small effect sizes are often important, as for example in life and death scenarios (Thompson, 2009), but in this case the effect size are indeed very small.

These data and the previously mentioned study could suggest that experience in childhood have a larger impact on restoration than in adulthood.

### **Stress and cognitive tests**

CRT claims that stress is the primary reason for the increase or return to baseline cognitive scores seen in studies. Berman and colleagues (2008) showed an increase in the executive control aspect of attention in ANT, as well as indications of increase in digit span backwards after exposure to direct and indirect nature. Although similar experiments with pre- and post test including manipulation is rare, the thesis would like to present some studies featuring similar increases in ANT executive control score.

**Short-term meditation training improves attention and self-regulation.** Tang and colleagues (2007) explored the impact of short-term traditional Chinese meditation training on participants. Amongst the dependent variables were ANT and its three primary measures; alerting, orienting and executive control. The influence of meditation training showed significant effect on executive control in the ANT. No difference was achieved on alerting or orienting. This is similar results to what Berman and colleagues (2008) showed in their study. In addition to executive control, significant results were achieved for stress as measured by cortisol levels. The study can somewhat be criticised for not reporting  $M$  and  $SD$ , which makes comparison to other studies somewhat harder.

Although similar results do not equal similar cognitive mechanism, it is nonetheless supportive of the fact that other interventions can give rise to an increase in executive control. This effect can come from mental training, as well as environmental stress, as the next study will show.

**Hyperthermia impairs the executive function using the Attention Network Test.** Environmental stress such as hypothermia also affects the executive function of participants. Sun and colleagues (2012) showed that participants scored lower on the

executive control aspect of ANT after residing in a room heated to 50°C for 60 minutes (Cohen's  $d = -0.89$ ). Alerting and orienting were not affected.

Although in the opposite direction of restorative studies, these data suggest that environmental stress affects the executive control of participants. This suggests that the executive control is generally influenced by stress or an increased state of arousal, while alerting and orienting is not. It also suggests that alerting and orienting are very hard to affect, even under such extreme conditions as 50°C for 60 minutes, which also can be considered to be somewhat questionable in regards to ethics.

There exist several studies which support CRT, and the author would argue most fits this framework better than established theory. Studies show that there are strong connections between previous experience with nature and its restorative effect. There exists environment which have the same effects as nature. Executive control can be influenced by general stress, which support the notion that the cognitive benefits of nature is mediated by stress. The thesis failed to identify any articles employing the ANT in an experiment and achieving significant differences in the alerting and/ or orienting subscore. This could indicate that nature does not affect only executive control because nature only affects this aspect, but because it is the only sub score in the ANT which is manipulable.

The thesis would go as far as to claim that it is close to impossible that the restorative effects of nature is not so *some degree* influenced by condition mechanisms, as close to all part of the CRT framework is already established in other fields of psychology.

It is not known why conditioning as a framework for the restorative effects of nature have not been previously explored. The most likely explanation could be that both the field of environmental psychology and evaluative conditioning are relatively new, and established researcher often have deep knowledge of only one or the other. As a newly educated researcher, the author has the advantage of recent experience with both, and hopes that the suggested framework for restorative environments will bring new knowledge and studies to the field.

### **Conditioned restoration theory and the cognitive benefits of nature**

Although already somewhat supported by data, an experiment was conducted that aimed to further explore the proposition of CRT. The study aims explore the proposition of previous experience on the restorative effects of nature, both in the type of experience and type of association. It was decided to use actual restoration in place of perceived restoration, as this was a weakness of several studies.

Although heavily implied in research, conditioning of the emotion arousal has not been directly linked to nature. It would be close to impossible to gather a significant sample which have no connection to nature at all. People which have not left urban areas are still exposed to parks, movies with nature, and stories, all contributing to conditioning. In addition, if a sample could be achieved, such an experiment could said to be unethical. Evaluative conditioning is very resistant to extinction. If a negative conditioning to nature was established, it would likely last forever.

One of the most direct ways of investigating CRT, as well as contributing to practical effects of nature, would be to investigate moderating variables of the cognitive benefits of nature. What variables moderated the cognitive effects of nature? Berman and colleagues (2008) investigated PANAS assessment of current mood, but it gave no results. PANAS does however not specify arousal or relaxing emotions, which CRT predicts. Central to the CRT is previous experience and relation to nature, so this should be investigated. If a regression model could be made that explain a large amount of variance in restoration, this would create strong grounds for arguments concerning which cognitive mechanism that created the restoration. There was particular interest in investigating how nature made the participants feel in childhood (1) and adulthood (2), their experience with nature in childhood (3) and adulthood (4). In order to create a model that accounted for the most amount of variance, baseline HRV (5) was added, as HRV represents the ability to relax and recover. Lastly, rumination (6) was added as it also represents the ability to relax, albeit on a more psychological scale, and to be used as a possible exclusion criterion.

In total, six possible moderating factors was included in the study, all believed to moderate the cognitive benefits of nature in some way. Participants earlier and present

experience with nature was very central. Regretfully, no existing inventory of question investigates this, so a inventory needed to be constructed.

### **Questionnaire validation: Methods**

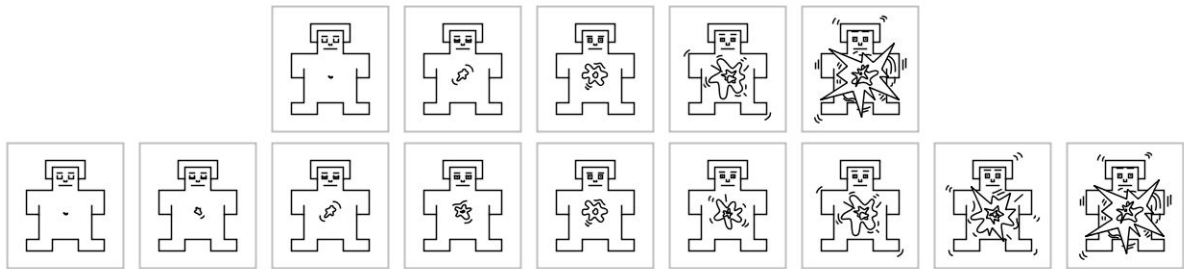
Vital to exploring CRT was assessing participants former and recent experience with nature. No inventory that measured this existed so to assure this was measured reliably, an inventory was created. The “Experience with Nature in Child and Adulthood”, ENCA, was generated. It was realized that the thesis did not have time or resources to generate the inventory adhering to all rules and guidelines, so some shortcuts were taken.

In short the gathering of items from several experts in the field was omitted from the process, and the author generated the items in cooperating with his counsellor. It is nonetheless believed that the process generated a solid inventory, in which process will be examined.

**Generation of items.** As mentioned, it was important to differentiate what type of experience and what frequency of experience. If a participant had none or very little experience with nature, they should according to evaluative conditioning theory receive limited restoration from nature. As early memories and experience was important, their experience in childhood was of specific interest. What type of experience participants was important, what type of emotion was the participants associating with nature? If a participant had experienced nature as a child as very arousing, they would according to CRT not receive as much restoration as participants which perceived nature as relaxing. How much participants liked nature, valence, was also important. For participants to enjoy nature and associate it with good memories, a positive valence had to be established.

Hence 2\*3 categories were established. Experience, arousal, and valence as a child and current situation. A solid assessment technique for arousal and valence already existed, the Self-Assessment Manikin (SAM; Bradley & Lang, 1994). Other options were considered, such as the Positive and Negative Affect Schedule (PANAS; Watson, Clark, Tellegen, 1988), but it was considered too lengthy for the inventories purpose. At the time, there was also strong considerations to assess the participants mood during the experiment with the SAM, so previous experience would be beneficial.

It was theorized that especially valence would be extremely positively skewed, with almost every reply representing a “i like nature” or “i like nature very much”. To counter this, a 9-point scale was adapted instead of the original 5-point scale. This was done to easy differentiations between the different levels of valence and arousal. The two scales for arousal are shown in figure 2.



*Figure 2: Differences between the 5-point and 9-point sam arousal scale (Watson et al., 1988).*

As no inventory existed to assess experience with nature, an inventory was created. Duration and frequency was created as potential subcategories, but showed no differences in the following factor analysis. A total of four items were created for experience in childhood, and five were created for current experience. Almost all the items can be viewed in the appendix, featuring a complete version of the inventory. One item was removed, Childhood\_exp\_3, which will be covered shortly. To minimize the risk of trash data, reply was always in relation to the question. For example, item “When i spend time in nature, i try to keep it short”, answers were labeled “never/ sometimes/ always try to make it short” on a 1-7 scale.

**Additional variables.** In addition to the variables mentioned, some other data collection was implemented in the inventory. Firstly biographical and biological data, gender, age and country was collected. It was also theorized that population density from where the participant grew up could affect scores, so location of upbringing was also collected though municipality.

An important step in validating an inventory is to correlate it with an existing inventory. This was especially important with the ENCA as item generation was done internally. The correlating inventory should be somewhat related to the primary inventory, so a mild correlation should be expected, albeit not a too strong correlation, as this indicated

the two inventories are measuring the same thing. It was decided to use the Love and Care for Nature scale (LCN; Perkins, 2010). LCN measures a “construct of love and deep caring for nature as an expression of people’s personal and explicitly emotional relationship with nature.” (Perkins, 2010, p. 1). In addition to having undergone a rigid validation process, it was expected the LCN should be correlated mildly with multiple items within the ENCA. This made it a perfect candidate for including in the ENCA survey as a correlation inventory.

In addition to this, it also would be interesting to test LCN as a moderating effect on the restorative effect of nature, which has previously not been investigated. On one side, a deeper emotional connection to nature could increase restoration, but in an CRT perspective, most of the LCN items reflects high-arousal values such as “I feel joy just being in nature”, “I often feel a sense of awe and wonder when I am in unspoilt nature”. These does not reflect relaxing emotions; which CRT predicts explains the restorative effects of nature. Investigating LCN correlation to ENCA *and* as a moderating factor for the restorative effects of nature would nonetheless be interesting and the scale was added to the inventory.

The questionnaire was generated through the website [www.soscisurvey.de](http://www.soscisurvey.de) which allows for customizing of question, scales and layout of the inventory, as well as making data collection and analysis simply.

**Questionnaire Pre-test.** A pre test was conducted to ensure that the ENCA questionnaire was understandable and unproblematic to participants. Target group participants were asked to complete the questionnaire and talk or “ramble” about what they are thinking about, while the author was present but silent. They were especially asked to mention aspects they found strange, confusing or problematic.

Four participants completed the pre test. All the participants used different electronic devices, to ensure the test had correct formatting on all devices. The devices were a Samsung S6 smartphone, Apple 5S Iphone, a Apple MacBook pro and the school's standard desktop computer running a windows 10 operating software.

Apart from some remarks regarding grammar and syntax, there was a problem with participants wondering what the data was going to be used for, and what the questionnaire is investigating. There was a problem with participants confusing the SAM Arousal



measurement with the Valence measurement, as the Arousal came first and was attributed valence values. One participant commented on the rigid male/ female classification of sex.

To resolve these issues a text was added to the start of the questionnaire to explain that all data was anonymous and the questionnaire aimed to investigate the participants relation and experience with nature. In addition the SAM Valence measurement was placed ahead of the Arousal measurement, to make it clear that there was a separate item for “how much one likes” being in nature. A “other” option was added for sex.

The ENCA was tested again on participants and there was found no significant confusion on any items and the questionnaire was deemed ready for the first round of validating.

**Sampling.** The sampling for the first round of the ENCA questionnaire was done by convenience sampling through the author's acquaintances. It was argued that it was not advantageously to fully publicize the ENCA due to the the first round of validation only required a 80-100 participants.

In an attempt to minimize the effect of a convenience sampling, the participants were recruited through the authors alphabetized facebook list, and everyone was asked to participate, regardless of their social standing with the experimenter.

**Data analysis.** The data was imported from the soscisurvey.de website through IBM's SPSS version 20 (IBM, 2011) in which the data was processed. All original data was separately stored on a local hard drive as well as google drive to make sure no data was lost. All participants that did not finish the ENCA on, based on the max page the participant visited, as well as soscisurvey.com's own “finished” variable, which correlated  $r = 1$ , was removed from the analysis.

Remaining was 92 replies considered valid. This including 49 females, 41 males, 1 other and 1 missing answer. A slight bimodal normal distribution in age ( $M = 28.61$   $SD = 10.02$ ) was noted, with a strong peak at 24 years old and a slight peak at 50 years old, likely representing two generation.

Factor analysis was used to explore the collected data. Factors with less than eigenvalue of 1 was excluded. The main purpose of the PCA was to confirm the existence of the two experience factors (child and adulthood), as well as different factors for arousal and valence. Factors less than 0.25 were suppressed and sorted.

**Missing values.** As with all questionnaire based surveys, missing values was expected and found. Little's Missing Completely At Random (MCAR) test was performed to investigate whether the values missing values was random or not, as suggested by Tabachnick and Fidell (2014). If values were missing at random actions can be taken to replace these. The MCAR test was found not to be significant  $p = 0.11$ , which means values was missing at random and can be replaced. The maximum likelihood method was used to fill missing data points.

There was however noted a bigger than usual missing data on both the SAM arousal values, 6.5, and 7.6 %, indicating that participants could have had bigger problems responding to this item. It was decided to add a explanation to the word "arousal" on future editions of the ENCA.

All reversed values were transformed using a "value = (8 - Value)" compute variable function in SPSS to ease interpretation of variables. Which variables was reversed was judged reading the questions and answers, as well as cross checking with the Pattern Matrix, which correlated  $r = 1$ .

### **Questionnaire validation: Results**

PCA revealed the following pattern matrix shown in table 1. The Kaiser-Meyer-Olkin value was .75, exceeding the recommended value of .6 (Kaiser, in Pallant, 2011) and Bartlett's Test of Sphericity (Bartlett, in Pallant, 2011) reached statistical significance  $p < .0005$ , supporting the factorability of the correlation matrix.

Table 1. Pattern matrix.

	Component			
	1	2	3	4
Adult_exp_1	.829			
Adult_exp_3	.823			
Adult_exp_5	.773			
Adult_exp_6	.721			.321
Adult_exp_4	.714			
Adult_exp_2	.683			
Childhood_exp_4		.883		
Childhood_exp_1		.832		
Childhood_exp_5		.800		
Childhood_exp_2		.654		.320
Adult_arousal			.936	
Childhood_Arousal			.783	
Childhood_Valence				.683
Childhood_exp_3				.661
Adult_Valence	.342		.293	.644

Pattern matrix confirms the presence of two underlying factors representing experience in adult and childhood, as well as two other factors representing arousal and valence.

A Cronbach alpha test was conducted to test the internal consistency of the subscales. The inventory as a whole achieved a Cronbach alpha coefficient of .85. This coefficient is however representing several subscales. The adult experience scale achieved a Cronbach alpha coefficient of .86, which is considered relatively ideal (Svartdal, 2009). The childhood experience scale however achieved a Cronbach alpha coefficient of .81. Although not extremely low, SPSS's "Alpha if item deleted" table, coupled with the items extremely skewed distribution (Figure 3), suggest removing item Childhood\_exp\_3 "The

first 13 years of my life, i rarely spent more than 15 minutes in nature per visit”. After removal, the Cronbach alpha coefficient for childhood experience became .85, considered to represent a superior scale.

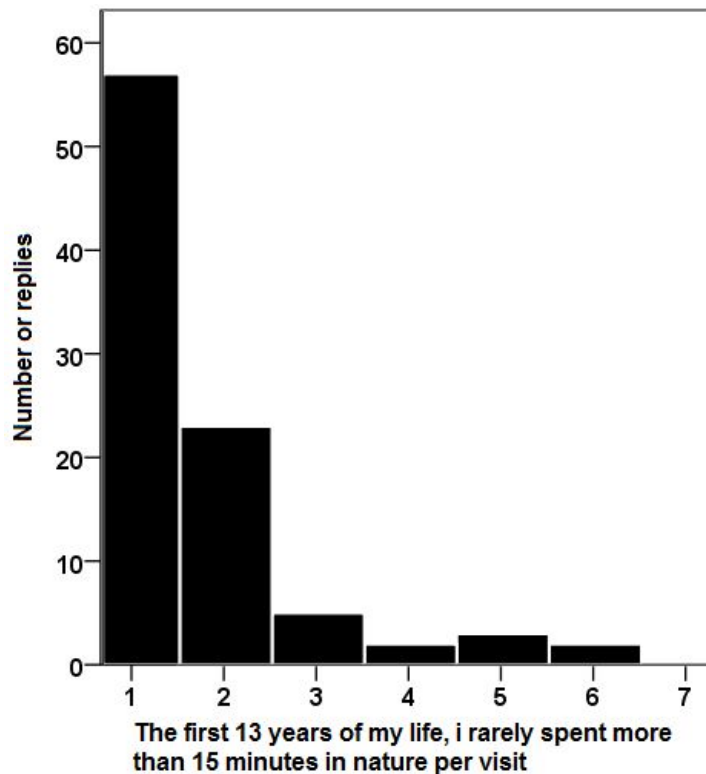


Figure 3. Distribution of item Childhood\_exp\_3 in the ENCA inventory. 1 - 7 represent level of agreement, 1 = “always more than 15 minutes” and 7 “never more than 15 minutes”

The following correlations were observed relating the ENCA and LCN. Experience wise, LCN ( $M = 4.60$ ,  $SD = 1.28$ ) had positive correlations with experience in child ( $M = 4.84$ ,  $SD = 1.20$ )  $r(90) = .26$ ,  $p = .01$ . and adulthood ( $M = 3.69$ ,  $SD = 1.08$ )  $r(90) = .53$ ,  $p < .0005$ , positive correlations with valence in nature in child ( $M = 7.38$ ,  $SD = 1.50$ )  $r(90) = .25$ ,  $p = .02$  and adulthood ( $M = 4.84$ ,  $SD = 1.37$ )  $r(90) = .43$ ,  $p < .0005$ , but no significant correlation with arousal in child ( $M = 5.47$ ,  $SD = 1.28$ )  $r(90) = .19$ ,  $p = .08$  or adulthood ( $M = 5.10$ ,  $SD = 2.01$ )  $r(90) = .16$ ,  $p = .13$ .

### Questionnaire validation: Discussion and changes

Factor analysis confirmed the presence of four factors, experience at childhood, experience at adult, valence and arousal. Experience and valence in adulthood had a medium strong positive correlation to LCN. The childhood experience and valence scales showed a weak correlation and arousal showed no correlation. This could indicate that the LCN scale and ENCA measures somewhat different variables. It is especially interesting that arousal showed no correlation to ENCA, as this was predicted. This could indicate that LCN represent a different emotional connection than arousal. The causal connection concerning experience and valence in adulthood is hard to establish, as individuals who do feel a care for nature will spend more time in it, as well as spending time in nature will also likely strengthen individuals connection to nature. The correlation to experience and valence in childhood is interesting, as this could indicate that persons which spent more time in nature and liked it will later develop a higher LCN score.

The following two changes was made. An explanation was added to the arousal item, based on Bradley and Lang's (1994) original work on transforming the semantic differential scale into the SAM, using the words excited, stimulated, awake, relaxing, sleepy or calming. As well as the Norwegian big medical leksikon definition of activating.

*What is arousal? Something that makes you excited, stimulated and wide awake. A stimuli that is not arousing is relaxing, sleepy or calming.*

*Arousal does not indicate whether you like something or not, just how "activating" you find the emotion you feel.*

Item Childhood\_exp\_3 was omitted from the ENCA, as it was a weak item, showing a extremely negatively skewed distribution and weak loading on the factor analysis.

Because relatively few changes were made to the ENCA, as well as the primary goals of the inventory was achieved, it was deemed suitable to be used as a measurement of experience with nature.

## Experiment

The ENCA was generated to validate items and scales which were to investigate moderating variables on the cognitive benefits of nature. Because the study needed to a Iv - Dv relation to test the hypothesized moderating variable of experience with nature, an experiment needed to be conducted. Studies have investigated restorative effects using items on a inventory (e.g. Collado et al., 2016), but it could be argued that this is not a valid measure of actual restorativeness. The best measurement on restorativeness could arguably be Ulrich (1984) study on patients recovery time from hospitals. A sample of hospital patients was however outside the thesis realistically achievable recourses.

Valid and practically reproducible results was found in a portion a research article by Berman, Jonides and Kaplan (2008), featuring pictures of nature, the ANT and backwards digit span test. The study showed significant effects of viewing pictures of nature to participants on the ANT executive control variable as well as suggestive results on the backwards digit span test. The PANAS emotional inventory was integrated in the experiment, but no significant findings were reported. The Berman, Jonides and Kaplan (2008) study have received much attention for its findings and could be argued to be one of the leading studies in environmental psychology.

The study wanted to replicate the Berman, Jonides and Kaplan (2008) study, but also improve some of its perceived weaknesses. Firstly the digit span test, in its mostly used format, could be considered to not be a reliable instrument relative to most other psychometric tests. The author tried to acquire the mean span test (Woods et al., 2010) by contacting the authors, but had no success in establishing contact. Readers are directed to the limitations section for a discussion on digit span and mean span.

### Experiment: Methods

A semi-double blind randomly assigned experiment featuring a 2x2 design featuring one control group and one experimental group were conducted.

**Ethics.** Regarding data anonymity, data was close to impossible to trace back to the participant if the participant was not assisting, both in the ENCA and experiment.

Participants left a code containing the first letter in their first name, number of letters in their family name, and second letter in their father's first name in the ENCA questionnaire. This code was retrieved during the experiment, which was linked to a ID from 1001 to 1031, only written down on an individual paper which was stored securely.

Test scores were never commented beyond “ok good”, or “very good” when scores were abnormally good. The author is not clinically educated and made no attempts to interpret individual scores. A small exception was made with one of the participants when the IOM Finger Sensors could not detect a pulse on the non-dominant hand, and a suggestion was made to follow this up with a physician. It was later revealed that the participant suffered from an undiscovered condition causing no palpable pulse unilaterally on the right side.

**Subjects.** Thirty-one (20 females, 11 males, age  $M = 24.4$ ,  $SD = 5.0$ ) Lillehammer College University students participated in the study. All participants were orally informed regarding matters of anonymity, freedom to leave, as well as the experiments purpose after data collection was complete. Participants were offered one piece of candy after data was collected.

**Measures.** The ENCA and LCN were administered prior to the experiment to conserve time, albeit some did not complete this and the inventories were administered prior to testing in the lab to some participants. Additional measurement was rumination, digit span backwards, ANT and SAM regarding valence, arousal and dominance.

The experiments primary dependent variable restoration, was measured through ANT and digit span backwards. ANT is a test developed by Fan, McCandliss, Sommer, Raz, & Posner, (2002) to assess the three attentional networks, alerting, orienting and executive attention. These three networks have shown to activate different regions of the brain through fMRI (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005). Differences were only believed to be found in executive control. The three networks are measured through differences in response time in the test. Participants are asked to reply through a keyboard which direction an arrow located at the screen is pointed, left or right. In some

instances the arrow is preceded with markers towards where it will appear, and when. The arrow is also sometimes accompanied by arrows pointing the same direction or the opposite direction. All attentional networks are measure by the difference in response time with or without these cues. Alerting is the difference in response time with or without a cue indicating timing. Orienting is difference in response time concerning where the arrow will spawn. Executive control represent difference in response time with accompanying arrows pointing the same versus opposite direction. A total of 288 trials represents one ANT, roughly taking 5\*3 minutes to complete. The test was downloaded from Fan (2016).

The experiment employed a digit-span backwards task to assess changes in directed-attention performance. Digit span procedure was based on the WAIS-III manual (Wechsler, 1997). Participants were asked to recite digits in reverse order, a task heavily dependent on attention (Cowan, 2001). Scoring was done according to Wechsler (1997), with one point awarded for each successful digit string. Participants received two strings containing the same amount of digits, if one or both were successful, the amount of digits increased by one.

For quick assessment of participants emotional state, the Self Assessment Mannequin (SAM) was employed (Bradley, & Lang, 1994), believed to be the most rapid and intuitive measurements of affection. SAM measures arousal, valence and dominance. All participants responded to these values by pen and paper. As the amount of measurements in the experiment increased, it was important to keep length under control, as an overly lengthy experiment would induce fatigue, as well as make sampling difficult. It was believed that particulary change in arousal could predict restoration, as it is the closest of the three measurements related to stress and relaxation.

Heart rate variability (HRV) baseline was believed to predict restoration, as it represents the ability to relax and restore bodily functions (Appelhans, & Luecken, 2006). Cardiac data was gathered with the Alive Clinical Version for IOM Sensors (SomaticVision, 2016), using the IOM Finger Sensors on the non-dominant hand. HRV was extracted from the data using the Artiifact software (Kaufmann, Sütterlin, Schulz, & Vögele, 2011)

A rumination scale was employed to assess participants ability to relax. The 10 item Ruminative Responses Scale (RRS; Treynor, Gonzalez, & Nolen-Hoeksema, 2003) were used to quickly assess rumination. Rumination is characterized by self-reflection as



well as a repetitive and passive focus on one's negative emotions, which could very likely inhibit restoration.

As a manipulation and independent variable, the same pictures used by Berman et al., (2008) were employed, collected from [www-personal.umich.edu/~bermanm/RestorationPictures](http://www-personal.umich.edu/~bermanm/RestorationPictures). This set contains two groups of pictures, "urban" and "nature", the first used in the control group and the latter used on the experimental group.

**Procedure.** When contacted, all participants were offered at least two times, one in AM and one in PM, to minimize potential tiredness. The testing took place in a enclosed lab, with no disturbance to data. Firstly it was checked if the participant had completed the ENCA and LCN, if not they were given time to complete them. Afterwards the RRS were administered, with the experimenter audibly making a point of not observing the participants scoring to minimize artifacts.

Following RRS, HRV baseline was established. The IOM Finger Sensors were connected to the non-dominant hand and participants relaxed for 6 minutes. Following HRV was SAM, with the experimenter explaining all three variables. The digit span backwards test followed.

The participants received the verbal instructions "I will now say some digits, listen closely and repeat them back to me when I am done". An example followed, "so if I say 1-2-3, you will say...?", all participants successfully responded 3-2-1, and the test started with the experimenter verbally reading the first digit string to the participant.

Following were a quite extensive explanation of the ANT, including flankers, incongruent makers and response time. Participants completed a 2-minute training session included in the ANT, all participants understood the how to complete the ANT prior to testing. As instructed in ANT, participants were led to believe that response time and accuracy were the what was measured.

After completion of ANT, participants completed the experiments picture viewing phase. E-prime randomly selected whether the participant received the control or experimental condition. Participants rated whether they liked the picture from 1-5, using a 5-point SAM valence scale using the keyboard. Although data were collected and investigated in the analysis, data collection were primarily to hide the main objective of this phase, to make participants view pictures.

After the intervention phase, participants again completed the SAM, digit span backwards and ANT test. The procedure for this was identical to the first, although explanations for the test were made shorter. Lastly the participants were debriefed regarding the experiments purpose, what the ANT actually measured and were free to ask any questions. Testing lasted about 80 minutes.

**Pre tests.** Three participants were gathered for a pre test, however one cancelled. The experiment went in large parts as planned, but a few unforeseen events was encountered.

Due to the experiments length, one participants needed to use the toilet close to the end of the experiment. If allowed to go this would disturb data collection. It was realized during processing of the HRV data that (1) using the current timestamping methods where one wrote down the time three times, differentiating between periods was extremely hard as there was a lot of extra time as explaining tests and transitioning, as well as (2) HRV data for testing was often unreliable due to finger movement. In the ANT, the test instructs one to use both index fingers for replying, which was changed to thumbs due to the IOM Finger Sensors already occupying the index finger, participants both found it hard to rest their hand at the keyboard, as well as using their thumb to press down a key disturbed the hardware, causing trash data. In the digit span test, participants sometimes lifted their hands to cover their eyes, touch their forehead in a “thinking” motion and other movements, also causing thrash HRV data.

It was quickly realised that asking participants to relax for the HRV baseline data collection sitting in complete silence with the experimenter present is a close to impossible task. An “awkward silence” was apparent, both for the experimenter and participants, which no doubt influenced the participants cardiac rhythm.

The experimenter had a orthosis for his hand during the first week of testing, which was scheduled to be removed some days into testing. Being a pretty rare and interesting sight, some of the participants found the orthosis interesting and perhaps distracting.

To resolve these issues, a note was added in the experiment schedule to ask participants if they needed to go to the bathroom, as they would not be able to do this during the experiment. Timestamps for HRV was changed from specific times to what time the actual tests started, ignoring HRV during instructional and transitional data. It was decided that the resting HRV and the HRV during the intervention (pictures) phase was to

be the primary HRV data used in the analysis. For the baseline HRV data collection, the experimenter left the room after telling the participants to do nothing, relax and he will be back in 6 minutes. Trash HRV data during digit span backwards testing due to hand movement was considered less crucial than to restrict the participant of hand movement, which could drain attentional resources, participants were not asked to relax their hands during digit span testing. To avoid difference in testing conditions, the experimenters orthosis was removed while testing.

**Data analysis.** Data was analysed primarily through google sheets, Artiifact (Kaufmann, et al., 2011) and SPSS version 20. Google sheets, a clone of Microsoft excel that stores data online and operates through the web browser chrome, was picked in favor of Microsoft excel because (1) it allows working on multiple computers without the need for transferring files, (2) allows for easier sharing of data with the author's supervisor, and (3) allows for safer storage of data, as google data centers are less likely to crash than privately owned storage devices. Regarding personal data safety, no data allowing for identifying the participants was stored online. Artiifact (Kaufmann, et al., 2011) was chosen because it is the best available HRV analytic software currently available, as well as both the author and the author's supervisor has experience with the software. SPSS was used as it is the leading brand in social science also in which the author has experience.

As the thesis wanted to predict change in score following manipulation from several independent variables, multiple regression was employed to analyze data. Only variables that had significant change in score compared to the control group were analyzed through regression. The thesis wanted to make it clear that the sample size used in the regression does not satisfy Tabachnick and Fidell's (2014) recommendations which suggest a ratio of 8 participants per independent variable, plus 50. Although the study operated with a full sample of 31 participants, one participant represents 288\*2 trials with the ANT, making each measurement very reliable. The model suggested is also theoretically sound, which also helps validate results. The regression analysis should regardless be interpreted with care considering a somewhat lacking power. The resulting model should be interpreted as pilot data that need to be supported by later replications. Several independent variables were explored in the regression, employing individual item in place of ENCA subscales gave the best model. This could be because Adult\_exp\_2 were one of the most directly objective measures on current experience with nature.

Scores were checked for normality and checked for outliers using the outlier labeling rule, multiplying the interquartile range by a factor of 2.2 (Hoaglin, Iglewicz and Tukey, 1986). No outliers were found. An alpha level of  $\alpha = .05$  was employed.

**Heart rate variability.** HRV data was analysed by running the raw data file output from the Alive software through the Artiifact software. pNN50 were primarily used during the analysis, meaning percentage of N-wave to N-wave greater than 50 ms, due to its resistance to sampling errors.

**Missing data.** During the experiment some data were lost. One participant hit the windows-left key which caused the monitor to flip, causing the test to be canceled. Technical difficulties with the ANT tests practice phase caused the post-manipulation ANT data to not register on two participants. IOM Finger Sensors would not record data on one participant. Missing data were not replaced. Cases containing missing data were used in analysis not requiring these data, for example participants missing data on the ANT test were still used in analysis of digit span backwards. Because all missing data were caused by technical difficulties, MCAR was not employed to investigate data.

It was realised during data analysis that timestamps for HRV data did not reliably represent the actual times beyond the baseline measurement. This was due to conflict in the Alive software recording missed readings as no data, and Artiifact interpreting no data as a leap in data. This made recorded HRV data correlate poorly with the actual time as the length of the reading passed. Consequently, HRV data was not investigated beyond the baseline.

## **Experiment: Results**

**Group differences.** A mixed between-within subject analysis of variance was conducted to assess the impact of two different interventions, viewing pictures of nature, or pictures of urban environments, on participants ANT scores and digit span backwards, on two times, pre-manipulation and post-manipulation. There was a significant interaction of time and manipulation, Wilks' Lambda = .86.  $F(1, 26) = 4.21, p = .05$ , partial  $\eta^2 = .14$  for the ANT executive control subscore, no other ANT sub score achieved significant results. The digit span backwards test also failed to show significant interaction of time

and manipulation Wilks' Lambda = .99.  $F(1, 28) = 0.20$ ,  $p = .66$ , partial  $\eta^2 = .01$ .

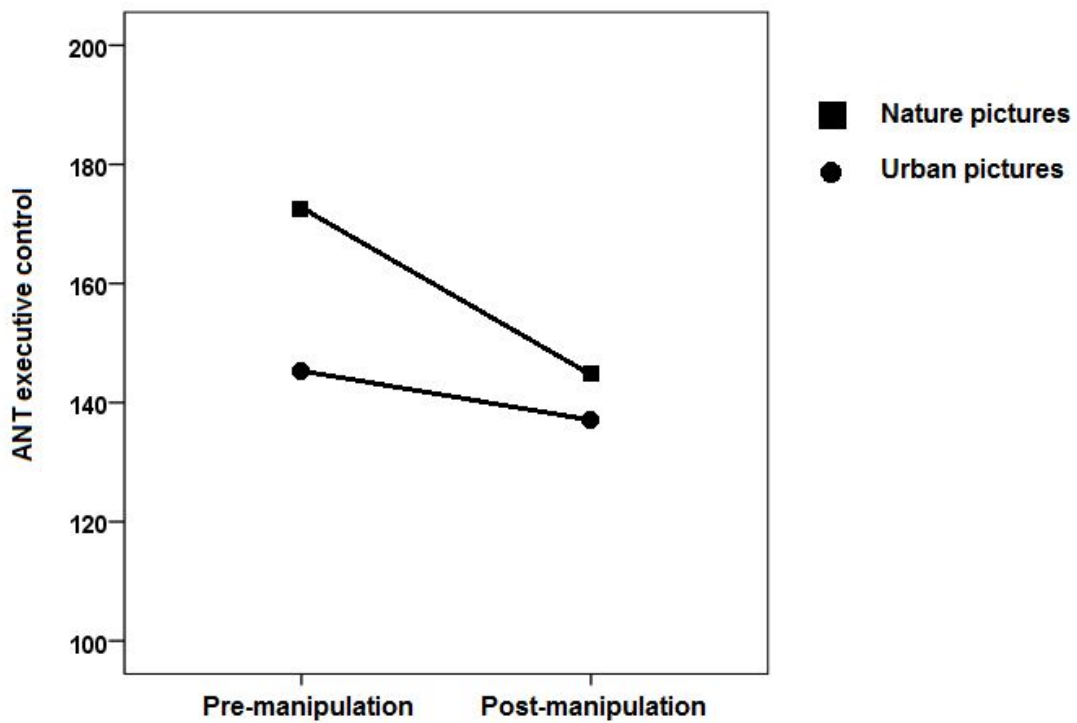
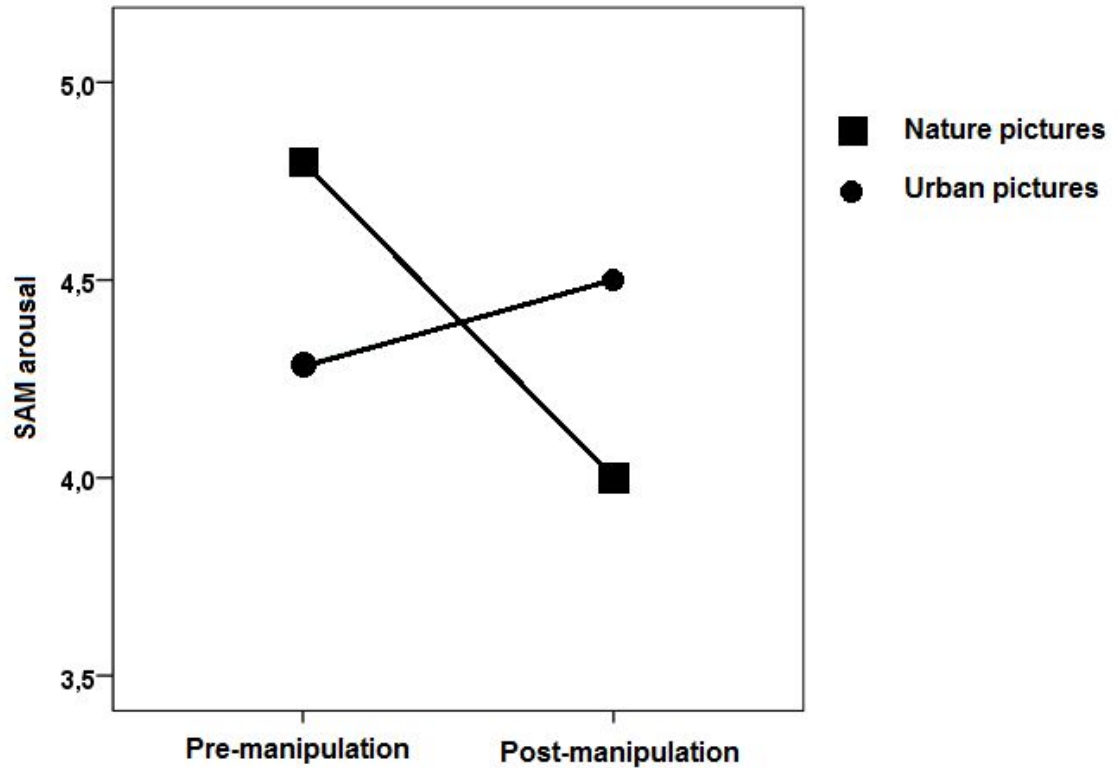


Figure 4: Change in ANT executive control scores from post to pre manipulation. Lower scores indicate better scores.  $p = .05$ .

Although digit span backwards failed to achieve statistical significance through the 2x2 ANOVA, investigating the numbers using t-tests, there was significant differences in digit span backwards in the experimental group from prior to manipulation ( $M = 5.56$   $SD = 1.97$ ) to after manipulation ( $M = 6.38$   $SD = 1.71$ )  $t(15) = 2.14$ ,  $p < 0.05$ , but not in the control group where scores prior to manipulation ( $M = 6.57$   $SD = 1.65$ ) were not different post manipulation ( $M = 7.07$   $SD = 2.46$ )  $t(13) = 0.82$ ,  $p = .43$ .

Similarly a mixed between-within subject analysis of variance was conducted to assess the impact of two different interventions, viewing pictures of nature, or pictures of urban environments, on SAM arousal, valence and dominance score, on two times, pre-manipulation and post-manipulation. There was a significant interaction of time and manipulation, Wilks' Lambda = .79.  $F(1, 27) = 7$ ,  $p = .01$ , partial  $\eta^2 = .21$  for the arousal subscore, no other SAM sub score achieved significant results. Executive control and arousal change is shown in figure 4 and 5



*Figure 5.* Change in SAM Arousal scores from post to pre manipulation. Lower scores indicate lower levels of arousal.  $p = .01$ .

**Regression.** Hierarchical multiple regression analysis was carried out to assess several control variables ability to predict levels of change in executive control score, mentioned above. Primary findings of the regression are listed in table 2. A summary of the models is found in table 3.

Table 2.

*Summary of the  $R^2$  in models.*

	Adjusted $R^2$	Independent variables
Model 1	.27	Love and care for nature
Model 2	.64	Love and care for nature ENCA item “In a average week, I spend some time in nature this many times”
Model 3	.80	Love and care for nature ENCA item “In a average week, I spend some time in nature this many times” Arousal in nature in childhood
Model 4	.87	Love and care for nature ENCA item “In a average week, I spend some time in nature this many times” Arousal in nature in childhood pNN50

Table 3.

Model 1 - stepwise regression, independent variable = LCN. Adjusted  $R^2 = .27$ ,  
 $F(1, 11) = 5.42, p = .40$

Variable	$\beta$	$p$ value	$B$	$SE B$
LCN	-0.57	.4	-7.05	3.03

Model 2. - stepwise regression, independent variables = LCN, ENCA Adult\_exp\_2  
 “In a average week, I spend some time in nature this many times”. Adjusted  $R^2 = .64, F(2,$   
 $10) = 11.78, p = .002$

Variable	$\beta$	<i>p</i> value	B	<i>SE B</i>
LCN	-1.03	.001	-12.62	2.64
Adult_exp_2	0.76	.005	17.56	4.98

Model 3. - stepwise regression, independent variables = LCN, ENCA Adult\_exp\_2  
 “In a average week, I spend some time in nature this many times”, Childhood\_arousal.  
 Adjusted  $R^2 = .80$ ,  $F(3, 9) = 16.56$ ,  $p = .001$

Variable	$\beta$	<i>p</i> value	B	<i>SE B</i>
LCN	-1.22	<.0005	-14.99	2.16
Adult_exp_2	0.96	<.0005	22.07	4.07
ENCA_Childhood_arousal	-0.42	.017	-4.35	1.50

Model 4. - stepwise regression, independent variables = LCN, ENCA Adult\_exp\_2  
 “In a average week, I spend some time in nature this many times”, Childhood\_arousal,  
 pNN50. Adjusted  $R^2 = .87$ ,  $F(4, 8) = 21.69$ ,  $p < .0005$

Variable	$\beta$	<i>p</i> value	B	<i>SE B</i>
LCN	-1.16	<.0005	-14.27	1.72
Adult_exp_2	1.11	<.0005	25.66	3.49
ENCA_Childhood_arousal	-0.45	.004	-4.71	1.18
pNN50	-0.33	.034	-0.32	0.12



## Discussion

Existing theories fall in explaining several aspects of the restorative properties of nature. Based on existing literature a framework focused on conditioning was developed. With help of a specifically developed and validated questionnaire an experimental study aiming to investigate CRT was conducted.

As predicted, the group differences are similar to those observed by Berman and colleagues (2008), making the findings more reliable. Two studies reaching close to identical results make the findings of both studies more reliable (Tabachnick & Fidell, 2014). The ANT executive control sub score was significantly improved in the experimental condition compared to the control condition. This indicate that viewing pictures of nature increases your executive attention compared to viewing pictures of urban environments. Alerting and orienting did not show any difference, but as previously discussed these sub scores have previously shown to be very hard to affect in an experimental design (Sun et al., 2013; Tang et al., 2007).

Digit span backwards only indicated improvement using two t-test. This means the score from pre- to post-manipulation were significantly different in the experimental group and not in the control group. But the change in score between the groups was not significant. It is likely that the non-significant result is the results of the digit span tests low reliability, as discussed in the limitations section and suggested by Woods and colleagues (2010). Further studies with higher power would likely achieve significant results.

In contrast to Berman and colleagues (2008) the study did achieve significant results in one of its mood variables. Data show that participants that viewed pictures of nature felt significantly less aroused than participants viewing pictures of urban environments. This indicate as CRT predicts that nature has previously been conditioned to a low-arousal emotion and exposure to indirect nature induce this emotion.

Regarding the regression analysis, it is again stresses that although the *p* values indicate significant results, the data should be interpreted as pilot data that need to be supported by later replications. The analysis does not satisfy Tabachnick and Fidell's, (2014) recommended power. In the latest model four variables, LCN, ENCA item "In a average week, I spend some time in nature this many times", ENCA item "Arousal in

nature in childhood” and pNN50 predicted 87% of the variability of change in executive control score. The thesis will discuss some aspects of the analysis, but will not interpret too heavily on its findings, as data need to be supported by replication to be reliable.

Several aspects are interesting in the following analysis. Firstly the constant negative beta weight of the LCN scale. Results suggested that LCN which represents individuals “love and deep caring for nature as an expression of people’s personal and explicitly emotional relationship with nature.” (Perkins, 2010, p. 1) have a strong negative influence on the restorative effects of nature. It was previously theorized that in a CRT framework, LCN would have a mild or negative impact on due to most of the items did not represent a calming or relaxing association with nature. One could argue LCN represents a high arousal emotional connection to nature, but in the ENCA data collection, arousal in nature in childhood  $r(90) = .19, p = .08$  or adulthood  $r(90) = .16, p = .13$  showed no significant correlation, so it is not a likely connection. A person that only spends leisure time in nature, should not develop a strong emotional bond, which again should facilitate restoration.

As an optional or additional explanation, the negative beta weight of the LCN scale could be as a result of its influence on pre-manipulation scores. LCN have been shown to correlate with subjective well-being (Tam, 2013). Although LCN did not show any correlation with the first SAM valence measurement  $r(31) = -.087, p = .64$ , which represents a baseline, LCN almost achieved significant results in correlation with the first ANT executive control test  $r(31) = -.323, p = .08$ , suggesting that the higher LCN, the better one performed on the first ANT executive control test. This could suggest that participants with a high LCN score were already at high executive control at the start of the experiment and benefited less from the restorative elements of nature, resulting in a negative influence on the improvement in executive control. No other value in the regression had trending results with the first ANT executive control score (all  $p > .32$ ).

A relatively high increase in explained variance is observed when the ENCA item “In a average week, I spend some time in nature this many times” is added. Statistical analysis can rarely differentiate causation and correlation (Tabachnick & Fidell, 2014) and it is likely that this item represents a non-causal connection. People that experience greater benefits of nature would consciously or unconsciously spend more time in nature. It is not likely that people that spend more time in nature would have a significantly stronger

conditional connection between nature and the emotion it is associated with. Evaluative conditioning research show that extinction is very limited. Once an association have been formed, lack of exposure to this connection does not reduce the association. This is of course assuming that evaluative conditioning applies to the restorative effects of nature, which is still a theory.

Arousal in nature in childhood increase the explained variance of the mode by 16%. A central argument to the CRT is that relaxing emotions is conditioned to nature. It was theorized that the primary emotion for this was arousal, but data suggest that emotions captured by the LCN could be more important. Nevertheless, emotion is very central to the model, LCN and arousal measurement accounts for 53% of the explained variance, which is a proportionally large part of the model, indicating that the emotions connection to nature is of importance to its restorative effect.

HRV represented by pNN50 was also theorized to impact restoration, albeit in a positive direction. HRV influence on restorativeness shows to be negative. A possible explanation could be that participants with a low baseline HRV were not able to relax on their own, but when exposed to nature, they were able to do so. The participants were not able to relax when instructed to, but were able to when viewing pictures of nature. This way participants that were not able to relax in for the baseline condition (low HRV) would achieve a “not restored score” on the pre-ANT test, and a “restored score” on the post-ant test, leading to higher perceived restoration on the results. This would however assume a correlation between the first ANT executive control test, but this is not the case  $r(29) = .014, p = .94$ . A possible explanation could be that individuals with a high HRV are capable of inhibiting attention to affectively significant stimuli (Park, Van Bavel, Vasey, & Thayer, 2012). Participants with a high HRV inhibited attention to the affective stimulus nature, which reduced restoration. It is regrettable that the experiment was not able to collect HRV data during the picture viewing, as this could help clarify the situation.

It could be argued that the primary supportive argument from the presented data regarding CRT in relation to other theories is that a regression analysis can be formed. Although the explained variance is artificially high due to low power, it is reasonable to assume it is still relatively high in more reliable data. This indicate that there are strong individual differences caused by emotional connection to nature, which CRT relies heavily

on. If the cognitive benefits of nature were indeed shaped by evolution, it is more likely that less variance could be explained.

Alternatively it could be argued that the emotional links to nature are caused by evolutionary traits. We have a predisposed affinity to associate nature with low arousal, which *can* be overwritten by conditioning. The thesis would however argue that there exists less support for this view compared to a conditionally view on nature. It is fully possible to explain close to all effects of nature using a conditional framework that can also be used on other environments.

CRT predicts that people that have a working relationship with an environment experience less restoration in that environment relative to other individuals. A sometimes overlooked point regarding this, is that nature is not one environment. It is likely that a park has different associations than a forest. For example, a professional city gardener would likely experience less restoration in a park, but not experience significantly reduced restoration in a forest. Similarly a fisherman could experience less restoration in environments containing water, but not parks.

CRT argues that the effects of nature does not originate from nature itself, which means the effects of nature could in theory occur in any environment. The author however would point out that it exists extremely few environments which are similar to nature and could give the same effects. Very few environments are so uniquely isolated and creates such a consistently relaxing environment as nature. Nature is therefore a practically unique environment, but the same effects could in theory be achieved by other environments. Different environments are also likely to condition different emotions, so it should be noted that one emotion is not likely to moderate all restorative effects of nature. In some instances, arousal could account for restoration, in other instances valence or other emotions.

If CRT shows to be valid, the science of restorative environments could advance tremendously. Studies, mechanisms and problems in the fields of associative learning could be applied to environmental psychology. This could help enlighten research question such as is nature restorative for everyone, how nature be made even more restorative, and is it possible to create environments to simulate the restorative effects of nature. It should be noted that within evaluative conditioning there is currently little agreement on a theoretical framework (Hofmann et al., 2010), so implementation could be difficult. This

alternative new CRT approach could help answering these questions if supported by further research.

### **Limitations and further research**

The experiment suffers from a limited sample size, especially in regards to the multiple regression analysis. Tabachnick and Fidell (2014) suggest  $50 + 8 \cdot I_v$ , which is far from the studies amount of participants in the regression. It is not recommended that further studies try to achieve the suggested sample size replicating the conducted experiment, unless considerable resources are available. Participants could not be scheduled any closer than two hours apart due to preparation, testing, debriefing and unforeseen events, and a sample size of 74 would require close to eight hours a day for four weeks excluding recruitment time, breaks, and cancellations, making a realistic testing time close to 7-8 weeks. Further studies investigating moderating effects should employ less time consuming tests measuring executive control, such as the Stroop test (Stroop, 1935). This would drastically reduce time required and make a good sample size easier to achieve.

It should be noted that because the experiment followed a standard test, manipulation, test format, and a portion of the participants were psychology undergraduates, some participants were able to correctly guess the experiments hypothesis before completion, which could have affected scores. None were however familiar with the ANT sub scores, so no conscious effort could have been made in directly affecting executive control. Although often making sampling significantly harder, further research should not use subjects familiar with an experimental design, as this could affect scores.

Some problems of the digit span test will be explained, but readers are directed to Woods et al. (2010) for a thorough review. Firstly a digit span test use unnecessarily long time to estimate a person's digit span score, participants that can handle 7 digits must first go through 2-6 digits, a total of 10 lines of digits before their capacity is actually tested. The scoring is extremely chunky, where one point equals one standard deviation, so differentiation between individual participants is hard (Woods et al., 2010). The digit span test had and do have some rest-retest reliability problems. Blackburn & Benton reports a correlation of 0.67, which is seen as low for a psychometric test (Svartdal, 2009).

Wood et al. (2010) introduced the mean span test, a version of the digit span test where the digit length increases when participants correctly reply, and decreases when participants fail. This allows for quick assessment with a score containing decimals. In the article, the mean span could predict several digit span test scores better than these could predict themselves, implying a very reliable way of scoring.

The new WAIS-4 features a new type of digit span test, digit span sequencing. The three tests combined, forward backwards and sequencing, features a test-retest correlation of 0,83 (Lichtenberger & Kaufman, 2012) which can be seen as acceptable, although far from good, as 0,83 represents the three tests combined.

On a personal note, the author has administered a fair share of digit span tests, probably around 500, and there seems to be vivid differences in the cognitive strategy participants choose to solve the test. Some chunk digits, clearly reporting 2 or 3 digits at a time, some rely on phonological short term memory, often copying the experimenters tone and dialect, while others rely more on visual cues, drawing the digits on a virtual touchpad on the table. In addition to this, there is some differences in participants behavior, where some cover their eyes, some say “ok, here we go” before reciting the digits, and some do nothing. Also comments at the end of the test such as “I tried different strategies of remembering the digits throughout the test” is far from uncommon. Although it is hard to prove these factors influence without fMRI or similar, it is likely that the digit span test does rely on different cognitive mechanism between participants, test sessions and even within a single test.

It is likely that the cognitive benefits of nature also apply to digit span backwards test, but the test suffers from low reliability, which significantly increases the power required for significant results (Svartdal, 2009).

CRT struggles in explaining some findings in environmental psychology, such as younger people's predisposition for liking a savannah environment. This was first investigated by Balling and Falk (1982), which found that 8 and 11 year old had a stronger wish to both live in and visit a savannah, compared to older subjects. The study can be criticised for achieving significance by showing that the younger group had significant differences through t-test, while the older groups has not. A more appropriate analysis would be a mixed between-within subject analysis of variance. CRT relies on learnt behavior, which does not include innate predispositions. This is however a minor

limitation, as the two phenomena can coexist, an innate predispositioned liking for certain environments and a CRT based restoration. CRT can still exist as a framework even though one has an inherent liking for nature. This is because CRT is not primarily based on valence, but arousal.

CRT primary weakness is possible that most of the theories it relies on has not been investigated in a nature - restoration setting, it simply assumes that similar mechanism should occur in this setting. Either evaluative conditioning nor placebo have not been investigated in a stress/ arousal - nature pairing. Especially evaluative conditioning could be criticised for relying heavily on lab experiments with limited real life findings (Hofmann, 2010). This nonetheless leaves room for further studies, which hopefully will support or reject CRT.

### **Summary**

The thesis suggests and presents a framework for the restorative effects of nature based on associative learning dubbed CRT. CRT argues that individuals learn to associate nature with a relaxing emotion, and later retrieve the same emotion when presented with an associated stimulus. It argues that most steps in this process have been established by other branches of psychology, and that several studies within environmental psychology supports a CRT framework. If CRT is to be found valid, findings and theory from conditional research could be applied to the field of restorative environments, which could stimulate a significantly leap in knowledge.

The study conducted investigated some of CRT's central arguments, that exposure to nature lowers arousal and the moderating factor of several variables. The study achieved similar results to Berman and colleagues (2008), indicating valid data. The study showed a support for a decrease in arousal, as well as an increase in executive attention. A regression model was formed that suggested a moderating effect of LCN, experience, arousal in childhood and HRV, but it is stressed that the regression model is primarily suggestive. Taken together, the data supports a CRT framework regarding the cognitive benefits of nature. Hopefully the presented theory and findings will stimulate further growth and research in the field of environmental psychology.

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Appendix.

Item 1, ENCA and LCN.



0% completed

## Hello and welcome

This survey looks at your experience with nature as a child and now, created by Lars Egner as part of his master thesis.  
All collected data is anonymous and can not be traced back to you.

### 1. How old are you?

Please write your age

  
years old

### 2. I am a

pick one gender

### 3. What country do you live in currently?

### 4. The first 13 years of your life, where did you spent most of your time?

For Norwegian participants, enter kommune. Other nationalities need not reply

Next







60% completed

19. Please rate these statements from strongly disagree to strongly agree

	strongly disagree	strongly agree
I feel joy just being in nature	○ ○ ○ ○ ○ ○ ○	
I feel that closeness to nature is important for my wellbeing	○ ○ ○ ○ ○ ○ ○	
When i am close to nature, i feel a real sense of oneness with nature	○ ○ ○ ○ ○ ○ ○	
I feel content and somehow at home when I am in unspoilt nature	○ ○ ○ ○ ○ ○ ○	
I feel a deep love for nature	○ ○ ○ ○ ○ ○ ○	
I often feel emotionally close to nature	○ ○ ○ ○ ○ ○ ○	
When I spend time in unspoilt nature I feel that my day-to-day worries seem to dwindle away in the face of the wonder of nature	○ ○ ○ ○ ○ ○ ○	
Protecting the wellbeing of nature for its own sake is important to me	○ ○ ○ ○ ○ ○ ○	
I feel spiritually bound to the rest of nature	○ ○ ○ ○ ○ ○ ○	
I feel a personal sense of interconnectedness with the rest of nature	○ ○ ○ ○ ○ ○ ○	
I often feel a sense of awe and wonder when I am in unspoilt nature	○ ○ ○ ○ ○ ○ ○	
I often feel a strong sense of care towards the natural environment	○ ○ ○ ○ ○ ○ ○	
I need to have as much of the natural environment around me as possible	○ ○ ○ ○ ○ ○ ○	
When in natural settings I feel emotionally close to nature	○ ○ ○ ○ ○ ○ ○	
I enjoy learning about nature	○ ○ ○ ○ ○ ○ ○	

Next

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80% completed

20. Secret code

It is possible that you will be asked to participate in a extremely fun experiment in relation to this questionnaire where there will be free chocolate.

To link this questionnaire anonymously, we ask you to write a secret code consisting of:

"First letter in your first name + Number of letters in your family name + Second letter in your fathers first name."

Next

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