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Abstract

Research indicates that natural environments can induce restorative effects on cognitive capacity and autonomic arousal, yielding improvements in cognitive functioning and more efficient heart rate restoration. The present study investigates differences in choice reaction time (CRT) and heart rate variability (HRV) in students (N=10) resting with or without a window view of a natural environment after a minor physical exertion. Subjects performed a pre-test of a Deary-Liewald choice reaction time task before pedaling a stationary spinning bike for five minutes, followed by 10 minutes of resting in a chair with either a window view of a forest dominated hillside and field land, or a neutral view of a plain interior wall. Subjects' heart rate variability was measured during the 10 minutes of rest, and post-test of the choice reaction time task was performed immediately after resting. Subjects elicited significantly larger improvement in CRTs after resting with a window view of natural environment, compared to resting with a neutral view. In addition, resting with a window view yielded significantly more efficient heart rate restoration, demonstrated by shorter heart rate restoration times. These results advance prior research by demonstrating both cognitive and physiological benefits of natural environments as a function of the same experimental manipulation, and offers support to both the attention restoration theory and the biophilia theory.

Introduction

A steady increase in urbanization is gradually diminishing human interaction with nature. Humans have evolved alongside nature, but in modern day civilization nature is often forced to give ground to metropolitan development. Economic and practical priorities tend to overcome aesthetic and recreational considerations, gradually pushing features of nature away from the cities. The occurrence of stress-related illnesses have increased rapidly in western societies the last decades (Ekman & Arnetz, 2005) yielding great impact on work absence, general health and well being (World Health Organization, 2001). In order to stay healthy, function properly, and cope with challenges and a performance demanding work life, humans are in need of both physical and mental restoration (Kaplan, 1995). Humans tend to seek out recreational activities and environments rich on nature in order to escape daily life stressors and urban noise (Cooper-Marcus & Francis, 1991). A large body of research has been devoted to investigate these recreational environments, and how they affect humans. These environments are commonly termed *natural environments*, and the potentially recreational effects that they might induce on humans are termed *restorative effects*. Mainly, the common conception in this field of research is that natural environments may have restorative effects on humans through recovery from cognitive fatigue (Kaplan & Kaplan, 1989; Kaplan, 1995) and through reduction of psychophysiological stress (Ulrich et al., 1991; Ulrich, 1993). However, the studies on restorative effects of nature are quite young and some areas of the current body of research remains fairly limited. The present author identified a need of high external validity studies employing measures of both physiological and cognitive restoration in natural environments. Hence, the present study attempts to contribute in that regard.

Defining natural environments and restoration

There appears to be a general agreement amongst researchers in this field regarding the definition of the term *natural environments*, providing a sufficient basis for doing research (Mausner, 1996). However, the meaning of "natural" can be highly ambiguous. Wohlwill (1983) attempted to create a definition useful for psychological studies. He contrasted a natural with a built environment and defined a natural environment as "the vast domain of organic and inorganic matter that is not a product of human activity or interventions" (Wohlwill, 1983, pp. 7). Hartig and Evans (1993) put emphasis on the *experience* of nature, and suggested that the subjective perception of whether or not an environment is a built environment or a natural environment is the crucial factor. This experience of nature does not necessarily have to occur in a specific type of environment. Several representations of nature, such as landscape paintings, photographs, video and virtual nature might cause a person to experience, reminisce, or have a sense of, being in a natural environment while actually being in a completely artificial environment (Hartig et al., 2011).

The present study utilizes the definition suggested by Hartig et al. (2011). The term natural environment is not meant to distinguish between untouched environments in the nature such as forests and mountains, and built environments such as roads, cities and buildings. Rather, a natural environment is simply a collective term describing an environment inducing the experience of nature, by containing genuine or artificial features of nature such as trees, flowers, water, landscape paintings or photographs. Environments that have the potential to be perceived as natural could be both a scenic hillside river surrounded my majestic snow-covered mountaintops, an inner-city park with apple-trees and fountains with fish, or even just a flowerbed outside an office window (Hartig et al., 2011). The key question in this field of research is how these natural environments affect people, and the most researched aspect of these effects is the *restorative* effects of natural environments.

The definition of the term *restoration* somewhat differs across different theories of nature restoration. Elaboration on this will follow later in the paper. However, Hartig (2004) proposes a suitable definition encompassing the crucial factors of restoration relevant in the current field of research. He defines restoration as “the renewal of physical, psychological, and/or social resources diminished in ongoing efforts to meet everyday demands” (Hartig, 2004, pp. 274).

Prominent research on restorative environments

Roger Ulrich (1984), to a large degree, pioneered this branch of research with his groundbreaking study on patients recovering from gall bladder surgery. He observed the recovery of 46 patients assigned at two different floors in a Pennsylvania hospital. One floor contained rooms with a window view to a small stand of trees, and the other floor contained rooms with a window view of a brown brick wall. His observations were astonishing. Compared to patients with a brick wall view, the patients with a view of trees had significantly shorter post-operative hospital stays, they required fewer and more moderate doses of analgesic, and the nurses reported that the patients were in a better mood.

These stirring results were tested in the following years, and more research implicated health beneficial potentials in natural environments. Early studies linked the perception of nature with stress reduction through decrease in blood pressure, electrodermal activity, and somatic facial activity (Parsons, 1991; Parsons et al., 1998). Later, several studies correlated perception of nature with higher pain tolerance (Lohr & Pearson-Mims, 2000; Tse et al., 2002; Park et al., 2004), and ease of pain (Diette et al., 2003). However, a large portion of the research in this field relies on subjective self-report studies. Cooper-Marcus and Francis (1991) conducted extensive questionnaires examining what situations and environments people seek out when experiencing negative emotions such as stress, anxiety and depression. 77% of the responses involved natural environments. De Vries, Verheij, Groenewegen and

Spreeuweenberg (2003) published a nationwide study where self reported information about health and amount of green space in living environment was collected from 10.000 Dutchmen. Green space was strongly correlated with health benefits. A recent questionnaire study done with over 4000 British respondents investigated recall of feelings of restoration in individuals returning from different natural environment visits. The results revealed that visits to coastal environments, forests, hills and mountains had the highest correlations with recall of feelings of restoration (White, Pahl, Ashbullby, Herbert, & Depledge, 2013). Early research also supports a link between exposure to nature and recovery from mental fatigue, demonstrated through cognitive performance tests and self-reports of affective states before and after wilderness experiences (Hartig, Mang & Evans, 1991). Developing interventions for cancer patients in natural environments have yielded therapeutic benefits in form of improved attention capacities (Cimprich, 1993), important for coping with mental fatigue associated with cancer (Valentine & Meyers, 2001; Lawrence et al., 2004). The use of healing gardens, therapeutic gardens rich on features of nature such as plants, trees, grass, flowers, water, birds and fish (Cooper-Marcus & Barnes, 1999), have also been shown to reduce emotional distress and experience of pain in pediatric cancer patients (Sherman, Varni, Ulrich, & Malcarne, 2005).

More recent studies have implicated that both being in genuine and artificial natural environments, restores several psychological abilities such as attention and focus (Berto, 2005; Berman, Jonides & Kaplan, 2008) and improve performance on cognitive tasks such as memory and reaction time (Lohr, Pearson-Mims & Goodwin, 1996; Berman et al., 2008). Even the mere presence of plants has been linked to positive effects on cognitive performance and mood (Lohr et al., 1996; Larson et al., 1998; Han, 2008). Some studies have also attempted to measure the physiological effects simulated nature has on humans. Simulated natural environments have been shown to reduce facial muscle tension and heart rate, and to prolong pulse transit times, compared to simulated urban environments (Ulrich et al, 1991; Parsons et al, 1998).

Cognitive capacity and Attention Restoration Theory

There are two prominent and influential theories that attempt to explain the restorative qualities of natural environments. One is the *attention restoration theory (ART)*, first suggested by Kaplan and Kaplan in 1989. Since then, several revisions have developed this theory into an extensive framework (Kaplan, 1995). In its essence, ART suggests that nature implicitly restores our capacity to direct our voluntary attention. Kaplan argues that having the capacity to direct our attention, also referred to as having a *restored cognitive capacity*, is necessary in everyday life in order to cope and function properly. Perhaps more familiarly, the ability to direct ones attention is equivalent to the ability to *focus*. Coping with tasks, challenges, activities and strives require our directed attention, and creates a need for restoration. If we are unable to restore our cognitive capacity, we become attention fatigued. Being attention fatigued over time leads to a physical and mental fatigue with negative effects on effective functioning, health and well being (Kaplan, 1995; Hartig, 2007). Being fatigued has been shown to increase the risk of several psychological and physiological problems and impairments, such as behavioral problems and depression (Fuhrer & Wessely, 1995; Rimes et al., 2007), and heart disease (Williams et al., 2010). Recent studies implicate that directed attention is important for short-term memory (Jonides et al., 2008). In addition, the ability to focus ones attention has been viewed as a crucial component of cognitive control, critical for school success (Diamond, Barnet, Thomas & Munro, 2008).

Kaplan (1995) proposes that being in the presence of either genuine or artificial features of nature attracts our involuntary and effortless attention which directly restores our cognitive capacity, which in turn improves our cognitive functioning. When our cognitive capacity is restored, the improvement in cognitive functioning will also be present in situations where natural features are absent. Kaplan suggests four characteristic properties that are significant in a restorative environment (Kaplan, 1995); the environment needs to induce (1) *fascination* in form of an effortless and interest-driven attention. In contrast to attention that requires effort, such as concentrating on a task even though redirecting ones attention to something else seem more compelling, the effortless attention of fascination provides a cognitive "breather" which enables restoration of the cognitive capacity (Hartig, 2004). The environment also needs to provide a sense of (2) *being away.* The individual needs to feel psychologically distant from everyday life and its tasks, strives and challenges which daily requires directed attention. In addition, the environment must have (3) *extent.* Fascinating impressions alone is not sufficient to be restorative, but the surroundings must have enough extent to constitute a whole environment. The surroundings must be an experience, rich enough on perceptions and impressions to engage and occupy a large portion of the cognitive capacity. Finally, the environment must be (4) *compatible* with ones purpose and desire. The environment must provide sufficient information and fit the individual's needs, in a way that makes the individual's natural behavior comfortable and appropriate in that specific setting; a feeling of belonging (Kaplan, 1995).

Kaplan (1995) suggests that when these four properties are present; when fascination of a rich environment occupies a large portion of our cognitive capacity, we distance ourselves from everyday-strives, and we are comfortable and feel like we belong – that is when our attention capacity is restored. It should be noted that restoration based on these properties is not exclusive to environments containing feature of nature, but according to Kaplan (1995), natural environments are the best known environments that contains these properties.

ART is used as theoretical grounds in numerous amounts of research on restorative environments, and the theory itself has been tested in several studies. To test the capacity of directed attention, or cognitive capacity, studies have often employed different types of attention-demanding tasks such as choice reaction-time tasks (Lohr et al., 1996; Laumann, Gärling & Stormark, 2003), the Necker Cube Pattern Control task (Hartig, Evans, Jamner, Davis, & Gärling, 2003; Berto, 2005), forwards and backwards digit-span tasks (Tennessen & Cimpirch, 1995; Berto, 2005; Berman et al., 2008), attention network tests (Berman et al., 2008) and Symbol Digit Modalities tests (Tennessen & Cimprich 1995; Berto, 2005), all in which have indicated that features of nature can improve attention capacities. However, a study conducted in office environments with or without numerous plants obtained results inconsistent with ART (Larsen et al., 1998). Productivity on a simple search task was lower in the plant environment compared to the non-plant environment, but the self reported mood and office attractiveness was improved.

Stress reduction and the Biophilia Theory

Another prominent theory, suggested by Ulrich and colleagues (Ulrich et al., 1991; Ulrich, 1993) emphasize that natural environments induce restoration through reduction of stress, or autonomic arousal. This theory is often referred to as the *biophilia theory*, and is based on evolutionary principles of genetically predisposed stimuli responses, such as the prepared learning theory proposed by Seligman (1970). The first humans are suggested to have existed for somewhere between five or seven million years (Haile-Selassie, White & Suwa, 2004). During our existence, we can presume to have spent the vast majority of our time living in natural environments. Seligman (1970) suggests that as humans have evolved in nature, we have adopted innate affective responses to our surroundings that foster our survival. These responses are either *approach* or *avoidance*, also known as *biophilic* and *biophobic* responses (Ulrich, 1993). Faced with threatening situations, such as encountering a hungry lion, our innate affective responses are dominated by fear which triggers avoidance behavior, a so called biophobic response (Ulrich, 1993). A biophobic response increases autonomic arousal (McNally, 1987) in order to physically prepare us to run, and our cognitive capacity is solely occupied with the task of fleeing the situation. More precisely, autonomic arousal is reflected by a decrease in parasympathetic activity and an increase of sympathetic activity categorized by increased heart rate, respiration, circulating catecholamines, electrodermal activity and electromyographic activity (Orizio et al., 1988; Ohuchi, 2000). Additionally, these responses are linked to increased neural activation in the amygdala (Parsons, 1991; Arnsten, 1998). The same physiological responses are observed when humans engage in attention demanding tasks (Brandenberger et al., 1980; Tulen Moleman, van Steenis, & Boomsma, 1989).

Anxiety or worry, another affective response, can also be explained as biophobic responses (Ulrich, 1993). For example, recollection of threatening experiences with hungry lions or stories about them can also cause biophobic responses, increasing autonomic arousal and occupying cognitive capacity. This process also works as a preparedness-mechanism (Seligman, 1970; Ulrich, 1993), in the sense that these recollections are automatically recalled when we encounter environments we associate with hungry lions. These avoidance responses leave humans in need of restoration, and that restoration occur in situations that affords *approach* behavior.

Approach behaviors occur when we encounter situations that are beneficial for our survival (Seligman, 1970; Ulrich, 1993). Walking on the scorching savannah after an unsuccessful hunt and spotting a piece of grass with a tree providing shade affords approach behavior. Resting in the shade surrounded by vegetation decrease autonomic arousal and requires a minimal amount of cognitive capacity. Hence, the spot of vegetation in the savannah affords both physical and cognitive restoration. Natural selection favored humans who learned and remembered these responses, thus these adaptive responses became innate and present in the gene pool (Ulrich, 1993; Laumann, 2004). Summing these principles, the main notion in the biophilia theory is that humans have an innate affinity with life and life-like processes that motivate and afford contact with restorative natural environments, whether it is animals, vegetation or views of forests (Ulrich, 1993; Hartig, 2011).

The biophilia theory proposes that humans are genetically predisposed to elicit three biophilic responses to natural environments*; approach*, *stress reduction* and *enhanced cognitive functioning* (Ulrich, 1993). Approach is a behavioral response, while stress reduction and enhanced cognitive functioning are effects. As described earlier, ART proposes an explanation of the effect of enhanced cognitive functioning in form of improved attention capacities. Ulrich (Ulrich et al., 1991; Ulrich, 1993) characterize the physiological components of stress reductions as a decrease in blood pressure, lower levels of circulating stress hormones and anabolic recharge of energy expending in the physiological arousal and behavior. Hence, cardiovascular measures and measures of hormone levels, as well as measures of electrodermal activity have been used as measures of stress reduction (Ulrich et al., 1991; Parsons et al., 1998; Hartig et al., 2003; Laumann et al., 2003). Failing to recover from stress may have several negative outcomes, both physically and mentally. Stress can cause immune suppression, which may exacerbate physical diseases such as cardiovascular, autoimmune and infectious diseases (Sapolsky, Romero, & Munck, 2000; McEwen, 2001). Prolonged stress can also lead to depression and anxiety disorders (World Health Organization, 2001; Ekman & Arnetz, 2005).

There are studies supporting the link between natural environments and stress reduction. Parsons et al. (1998) measured stress indicators (increased electrodermal activity, elevated heart rate and blood pressure) of 160 subjects during and after a simulated drive through either urban or natural environments. The results revealed indications of more efficient stress recovery after the nature drive compared to urban drive, but the results were not fully convincing. Laumann et al. (2003) found that subjects watching videos of natural environments elicited lower heart rate measures compared to subjects watching videos of urban environments.

Psychophysiological research on restorative environments

In psychophysiological research, physiological measures are used to index psychological constructs (Blascovich, 2004). The aim of such research is to obtain psychological and physiological measures of the same phenomenon. These measures provide a broader understanding of the phenomenon at hand, and allows for correlations between them to be analyzed. After extensively reviewing studies and literature in this field of research, the present author is of the impression that the amounts of psychophysiological studies on restorative environments are limited. The present study applies psychophysiological measures. Hence, some relevant studies applying this method will be addressed in the following section.

Chang, Hammitt, Chen, Machnik, & Su (2008) applied electroencephalogram (EEG), electromyogram (EMG) and blood-volume puls (BVP) measures combined with self-report questionnaires. The aim was to investigate congruency between physiological measures of restoration and self reported psychological restoration. Measures were taken during and after subjects watched several pictures of natural environments. The results revealed congruency between the subjective experience of nature and the physiological measurements of stress reduction and attention restoration. The subjective feeling of perceived restoration corresponded to decreased blood pressure and increased cortical activation. However, the experiment did not include any control conditions, thus there are no certainty that an equal pattern of results would not occur with the use of other pictures, such as urban pictures.

Perhaps the most prominent psychophysiological study on restorative environments to date is a study done by Hartig et al. (2003), where both stress reduction, attention capacity and self reported mood state was measured in natural and urban environments. Stress reduction was indicated by repeated measures of both systolic (SBP) and diastolic blood pressure (DBP). Attention capacity (AC) was repeatedly measured by utilizing a Necker Cube Pattern Control task (NCPC) and a memory-loaded search task (Smith & Miles, 1987). Subjects underwent pretests where blood pressures (BPs) were measured and AC was tested, before a drive to either an urban or a nature-rich field site. On arrival, BPs was measured again before subjects were assigned to a task group and a non-task group. The task group was assigned to complete a Stroop task and a binary classification task during a period of one hour in order to induce attention fatigue. The non-task group skipped this step. Following, both groups were assigned to sit for ten minutes in a room with a window view of trees or in a room with no view. BPs was measured during and after. Then the subjects went on a 50 minutes' walk in either a natural or an urban environment. BPs, AC and mood were measured during and after the walk. BPs decreased during the natural environment-walks, and increased in urban walks. However, these differences were evened out at the end of the walks. The natural conditions also produced more positive self reported emotions. The environment conditions had no significant influence on performance on attention tasks. Performance slightly declined in the urban condition, and slightly improved in the natural condition, but the results were not sufficiently convincing to draw any conclusions and should only be viewed as mild indications. However, DBP of subjects sitting with a view of trees declined significantly more compared to no-view subjects, both in task and no-task groups (Hartig et al., 2003).

Although the study done by Hartig and colleagues is methodologically thorough and solid, the complexity of the design allows for several potentially confounding variables. For instance, BP measures showed that the drive to the field site served as a stressor for the non-task group, and this might have influenced them during the remaining experimental conditions and skewed the data. The researchers report an overall effect of decline in anger and aggressiveness in the natural conditions, but the only condition that elicited a decline was the no-task group in the natural condition. Subjects assigned to the task group with a following natural environment-walk actually reported increased anger and aggressiveness. The view of trees and non-view conditions gave solid physiological results, but no psychological measures (AC or self reported mood state) were taken directly after the 10 minutes rest with or without view, making it difficult to judge whether or not the decline in DPB was accompanied by any psychological effects.

Given that natural environments do restore attention capacities as suggested in the attention restoration theory (ART), one would expect performance on attentionally demanding tasks to improve in the presence of natural environments (Kaplan, 1995). Lohr et al. (1996) and Laumann et al. (2003) have applied choice reaction time tasks, where performance is dependent of both cognitive processing and ability to respond quickly, to measure attention restoration in natural environments. Choice reaction time tasks are attentionally demanding tasks which can be used as objective measures of processing speed capacity (Salthouse, 1996; Madden, 2001; Jensen, 2006; Deary, Liewald & Nissan, 2010), transferable to the terms cognitive capacity or directed attention which are used in ART (Kaplan, 1995).

Lohr et al. (1996) investigated how the presence of interior plants affects performance on a choice reaction time task, while measuring heart rate and systolic blood pressure (SBP) during performance. Results revealed that the presence of plants improved choice reaction time with 12% compared to absence of plants. SBP increased in both conditions, indicating that the reaction time task served as a stressor, but SBP increased significantly less with the presence of plants. In other words, the results indicated that the presence of plants increased cognitive capacity and made the task less stressful. However, no significant differences in heart rate measures were obtained.

Laumann et al. (2003) tested how being exposed to video simulations of natural and urban environments affects attention restoration and autonomic arousal. A proofreading task was used to induce attention fatigue. They applied an attention-oriented reaction time task to measure attention restoration, utilizing endogenous cues to measure reaction time of voluntary attention, and exogenous cues to measure reaction time of involuntary attention, in addition to applying both valid and invalid cues in order to measure a validity effect. They used measures of heart rate variability (HRV) to index autonomic arousal. HRV is a precise measure of inter-beat intervals (ms between each heart beat), and is widely used to gain insight into how the autonomic balance between sympathetic and parasympathetic activity affects the cardiovascular system (Freeman et al., 2006). There were two experimental groups, one assigned to watch the nature video and the other to watch the urban video. The results revealed that the nature group had significantly longer inter-beat intervals (lower heart rate) compared to urban group during exposure to video, indicating lower autonomic arousal. Both groups improved performance in the post attention tasks. However, the nature group did not perform better than the urban group. Hence, the attention task results did not support the attention restoration theory.

The study by Laumann et al. (2003) provides an important contribution to this field, seeing as their simulated natural environments elicited significant physiological effects, but no effects of attention improvement. They apply an explanation derived from Easterbrook (1956) and Eysenck (1982) and suggest that a decrease in arousal cause a decrease in attentional selectivity. Being less attention selective will increase amount of processed cues which will in turn cause a slower response. Hence, Laumann et al. (2003) suggest that on simple tasks that do not require a broad attentional selectivity, increased arousal will improve performance. However, if this explanation was adequate, you would in contrast to their results expect attention performance to drop in the post attention task, seeing as both groups elicited lower physiological arousal during the post attention task compared to the pre attention task. A recent study indicate that resting in genuine natural environments yields more effective restoration and stress reduction compared to resting in simulated environments (Kjellgren & Buhrkall, 2010). Hence, the stimuli used by Laumann et al. (2003) might not have provided a sufficient experience of nature in order to induce attention restoration.

The psychophysiological studies mentioned above have advanced the understanding of the relationship between cognitive capacity and stress reduction as a function of the presence of natural environments. However, the results are contradictive and raise several questions. Concerning cognitive restoration, the present author does not view the existing research as sufficient to make generalizations. A great amount of studies have linked natural environments to a reduction in physiological arousal (Ulrich, 1991; Parsons, 1991; Parsons et al., 1998; Hartig et al., 2003; Laumann et al., 2003), but apart from the study by Lohr et al. (1996), there is an absence of studies eliciting physiological restoration accompanied by strong effects of cognitive restoration as a function of the presence of natural environments. More simple and objective measures which can easily be replicated seem necessary, and the current study aims to contribute in that regard.

Current study

The goal of the present study was to investigate how resting with a window view of a natural environment after a physical stressor affects cognitive capacity and heart rate restoration. The experiment was designed as a further development of the psychophysiological studies done by Hartig et al. (2003), Lohr et al. (1996), and Laumann et al (2003), with the aim of reducing the amount of potentially confounding variables, increase precision of measurement and provide external validity. In line with the study done by Lohr et al. (1996), a choice reaction time task (CRT) was applied in order to measure cognitive capacity.

Heart rate measures have been extensively used as a measure of physiological restoration in this field of research (Ulrich, 1981; Lohr et al., 1996; Parsson, 1998; Laumann et al., 2003), hence measures of heart rate variability (HRV) was applied to index physiological restoration. HRV provides insight into how the autonomic balance between sympathetic and parasympathetic activity affects the heart rate (Freeman et al., 2006). Studies in the field of physiology commonly measure restoration during the first few minutes after a physical excertion, and heart rate restoration during this period have in several studies been identified as good indications regarding degree of parasympathetic activity, known as parasympathetic tone (Arai et al, 1989; Imai et al., 1994; Ohuchi, 2000; Dogru, Gunaydin, Simsek, Tulmac, & Guneri, 2007). Thus, transferred to the terms used in the biophilia theory (Ulrich, 1993); HRV measures immediately after a physical exertion can provide indications of autonomic arousal and stress reduction during restoration.

Genuine natural environments have been shown to yield more effective restoration compared to artificial natural environments (Kjellgren & Buhrkall, 2010). Hence, regarding validity, an outdoors natural environment would be the ideal setting for testing the hypotheses. However, conducting controlled experiments outdoors offers a great amount of potentially confounding variables and practical challenges. Thus, the present study employed a balance of validity and reliability by conducting the experiments in a controlled indoor environment with or without a window view of genuine nature.

The experiment share several similarities with prior research in order to enable comparisons of results. However, no study to date has applied the combination of CRT and HRV as measures of the restorative effects of resting with or without a view of genuine nature, hence the study is partially exploratory. However, based on the prior research noted above, two primary hypotheses and one secondary hypothesis were outlined. The first primary hypothesis was based on the results obtained by Lohr et al. (1996), and states that (1) resting with a window view of a genuine natural environment after a physical stressor yields significantly shorter choice reaction times compared to resting without a view. The second primary hypothesis is exploratory, and states that (2) resting with a window view of a genuine natural environment after a physical stressor induces more efficient heart rate restoration compared to resting without a view. In addition, based on the results obtained by Hartig et al. (2003) and Laumann et al. (2003), (3) subjects are expected to elicit lower mean heart rate during 10 minutes of rest with a view of a genuine natural environment, compared to resting without a view.

Method

Design

The current study employed a pre test – post test within-subjects design, in a repeated measures experiment. Subjects performed a pre-test of the Deary-Liewald Choice Reaction Time task (Deary et al., 2010) (CRT task) before a minor physical exertion (five minutes of pedaling on a spinning bike) followed by 10 minutes of resting in a chair. After pedaling and resting, they performed the post-test of the CRT task. Heart rate variability (HRV) was measured during physical exertion and resting period. The experiment was conducted with two different experimental manipulations; (1) resting with a window view of a natural environment, and (2) resting with a neutral view. Choice reaction times and HRV measures were outcome variables. All subjects performed the experiment with both manipulations in two separate sessions. Condition order was randomly assigned with five subjects performing the window view condition in the first session, and six subjects performing the neutral view condition in the first session. The design is demonstrated in figure 1. The study was accepted by the Norwegian Social Sciences Data Service (NSD).

	Experimental design				
	Step 1	Step 2	Step 3	Step 4	Step 5
Session 1	Questionnaire	Reaction time pre-test	Cycling 5 min	Rest in **View/neutral** environment 10 min, 30 sec	Reaction time post-test
Session 2	Questionnaire	Reaction time pre-test	Cycling 5 min	Rest in **Neutral/view** environment 10 min, 30 sec	Reaction time post-test

Figure 1. The experimental design, in steps. Independent variables are highlighted.

Subjects

A number of eight subjects were set as a minimum requirement. The sample surpassed the minimum and 11 male students from the floorball team at the Norwegian University of Science and Technology were recruited through enquiry (*M*age=23,55, *SD*=2,34, age range: 21-29 years). Recruiting players from a floorball team as subjects ensured some control of physical fitness and exercise routines, seeing as all subjects engaged in the same physical activity five hours a week. Subjects needed to fulfill some criteria regarding alcohol and caffeine consumption in order to inhibit substance influence on heart rate variability (Wiklund et al., 2009). Alcohol, or an unusual amount of caffeine, was not consumed during a time of 24 hours prior to the experiment. In addition, no caffeine or taurine was consumed during the time of two hours prior to the experiment. Information about criteria, demographics, as well as information regarding potential confounds, were gathered through a questionnaire (q=10) (Appendix). All subjects gave their informed written consent and were told that they could withdraw at any time. The physical exertion was limited, and reaching the desired heart rate level required a moderate level of intensity. Hence, the experiment posed no threat to the subjects' physical health.

One subject was excluded due to a fire alarm going off during the experiment. HRV measures from one subject were incomplete due to a technical error, hence excluded from analysis. CRT measures from this subject were successfully obtained and included in analysis.

Experimental conditions and set up

The experiment was carried out in a spinning gym at the Dragvoll Sports Center in Trondheim. The rear end of the gym had large windows facing a forest dominated hillside and field land. There were two experimental settings, an activity setting and rest settings. The activity setting consisted of a spinning bike and a computer placed in the middle of the gym. The window view was blocked by venetian blinds during this setting. There were two different rest settings; a view environment and a neutral environment. The view environment consisted of a chair facing one of the large windows with a view of a natural environment (see figure 2). The neutral environment was the same chair facing the side wall of the gym at a distance of four meters. The wall had two colors, light salmon (hex: FFA07A) and steel blue (hex: 4682B4) split by a white molding (see figure 3). Venetian blinds blocked the window view in this condition. The purpose of this was to eliminate the visually perceived experience of nature without altering other variables such as place, temperature and quality of air. The gym had comfortable lighting, and was aired before every session in order to ensure good quality of air. The experiments were carried out from November to February, and were done under as similar weather conditions as possible. Weather variables such as cloudiness, amount of sun, amount of snow, and subjects' subjective comments concerning the weather was noted in order to test for confounding effects.

Figure 2. The window view from the gym at the Dragvoll Sports Center. A forest dominated hillside and field land. The view was used as experimental manipulation. The grounds and trees were partially covered in snow during the time of experiments.

Figure 3. Panorama picture of the interior wall in the non-view experimental manipulation. The wall was in the colors of light salmon and steel blue split by white a molding.

Equipment

Heart rate measures. Heart rate variability (HRV) was recorded with a Polar RS800CX device and a Polar W.I.N.D heart rate monitor belt, which provides measures of inter-beat intervals (IBIs) (milliseconds between each heartbeat) through recording every heart beat in the precision of milliseconds. Higher IBI value corresponds to lower heart rate. Polar Windlink was USB-connected to a Hewlett Packard Lap Top (model Pavilion dv6) running Polar ProTrainer 5 software, to ensure live monitoring and recording of HRV. The recorded data was saved and analyzed in the Polar ProTrainer 5 software.

Choice reaction time measures. The Deary-Liewald Choice Reaction Time task is a standardized computer-based reaction time test (Deary et al., 2010). The test was set up on a table in the middle of the spinning gym and run on a 15,6" HD LED screen with a refresh rate of 60Hz. Subjects were seated with their eyes approximately 50cm from the screen. The task consisted of four white squares positioned on a horizontal line in the middle of the screen set against a blue background (see figure 4). Four keys on a standard computer keyboard corresponded to each of the squares. The 'z' key corresponded to the far left square, 'x' key to the square second from the left, 'comma' key to the square second from the right, and the 'full-stop' key to the square far to the right. Subjects were instructed to rest their index and middle fingers on the keys. A stimulus in form of a cross appeared randomly in of the squares, and the subjects were instructed to respond as quickly as possible by pushing the key corresponding to the square containing the cross. The cross remained in the square until a key was pushed, after which it disappeared and reappeared in one of the squares shortly after. The inter-stimulus interval was randomized and ranged between 1 and 3 seconds. 80 trails were run per test, with 8 practice trails before the start of every test. The computer program recorded response time for each cross, inter-stimulus interval for each trail, and whether the response was correct or wrong. The program also calculated the mean, median, variance, standard deviation, skewness and kurtosis of the response times.

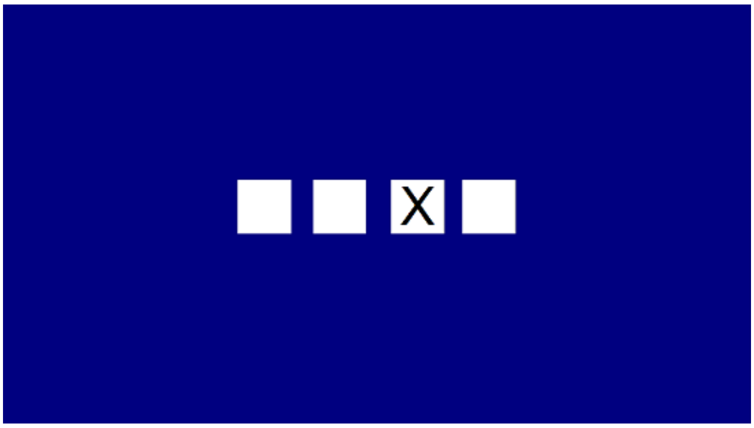

Figure 4. Screenshot from a trail of the Deary-Liewald choice reaction time task.

Procedure

At arrival the subjects gave their informed written consent and filled out a quick questionnaire, involving demographic questions as well as questions about exercise history the current week, current mood state, health and amount of sleep the previous night (appendix). The heart rate monitor belt was mounted on the subjects and its functionality was tested. The spinning bike was adjusted comfortably according to the subjects' leg, arm and upper body-length. The experiment began in the activity setting where the subjects performed the pre-test of the Deary-Liewald Choice Reaction Time (CRT) task. When completed, they were seated on the spinning bike and rested for a few minutes in order to stabilize their heart rate. The researcher was seated to the left of the subjects and monitored the live heart rate recording. The subjects' baseline heart rate was noted (e.g 80), and they were asked to pedal the bike for five minutes. At the end of these five minutes, the researcher made sure the subjects exceeded at least a 60% increase of the noted baseline heart rate (128) with a steady progression by increasing intensity through both asking the subjects to pedal faster and adjusting the pedal resistance. After the five minute pedal, the subjects immediately moved over to one of the rest settings (neutral or natural view) where they rested for 10 minutes while the researcher left the room. At the exact time the subjects sat down in the resting chair, the researcher pushed 'new lap' in the live recording software in order to mark when the restoration period began. The subjects were only instructed to rest. The researcher returned 10 minutes and 30 seconds later in order to ensure 10 minutes of undisturbed rest-data. Then the recording was stopped. After the restoration period, the subjects moved back to the activity setting and performed the post-test of the CRT task. In one to seven days, the subjects returned to repeat the experiment with the other rest setting.

Data transformation and calculation

Prior to conducting the study, a sample size of 8 to 12 subjects was seen as appropriate and probable. Small sample sizes tend to violate the assumption of normal distribution (Field, 2007). Hence, the present study applied non-parametric analysis to test the hypotheses.

To test hypothesis 1, choice reaction time values (CRTs) from pre-test measures and post-test measures were used as variables in a related samples Kendall’s coefficient of concordance test. In addition, pre- to post-test CRT improvement was calculated. Mean CRT from the pre-test (e.g. 350ms) vas subtracted with the mean CRT from the post-test (e.g 310ms), providing a post-test CRT improvement value (e.g. 40ms).

To test hypothesis 2, efficiency of heart rate (HR) restoration was indexed by restoration time. The heart rate recording from each session lasted approximately 17 minutes (two minutes to stabilize HR, five minutes pedaling and 10 minutes of rest). Prior to physical exertion in every session, a baseline HR was noted (e.g. 80). A 60% increase of the baseline HR was calculated (e.g. 128), and subjects gradually increased intensity and exceeded the 60% increase after five minutes of pedaling. To ensure accurate measures of heart rate, inter-beat intervals (IBIs) were used as values to calculate restoration time (Berntson, Cacioppo, & Quigley, 1993; Laumann et al., 2003). Pressing “new lap” in the recording software at the exact time the subjects sat down to rest provided a peak IBI value from each session (e.g. 485 ms and 515ms). The standard method of pedaling to a 60% increase of baseline HR ensured that the peak IBI values did not differ much. The two peak IBI values were averaged (e.g. 500

ms), giving an averaged peak value (APV). A 50% increase of the APV was calculated (e.g. 750ms), giving an *averaged low value* (ALV). The time elapsed between the closest points of APV and ALV was the restoration time. To calculate restoration time, the time of which the subject reached the ALV during restoration period (e.g. 07:30 min) was subtracted with the nearest time of which the subject's heart rate was at the APV (e.g. 06:45 min), giving a *restoration time value* (e.g. 45 sec). A two independent sample Mann-Whitney U test was carried out with restoration time as test variable and experimental manipulation (natural or neutral) as grouping variable. An illustration of heart rate measure and extraction of restoration time is given in figure 5.

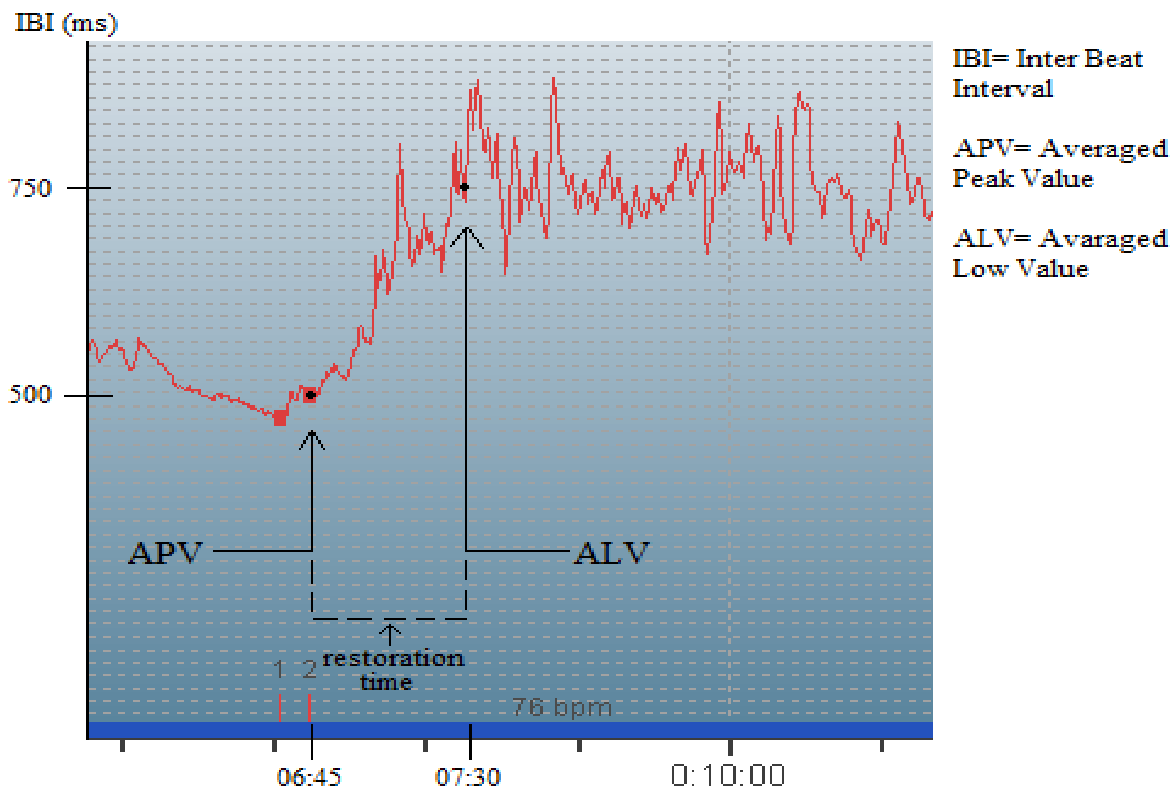

Figure 5. Screenshot from the Polar Pro Trainer software, illustrating extraction of restoration time. Red curve is heart rate variability. Y-axis represents IBIs in milliseconds, X-axis represents time. Black dot to the left is the APV, black dot to the right is the ALV. Time between APV and ALV is the restoration time. Values in this illustration are fictional.

To test hypothesis 3, mean HR during the 10 minutes of rest in both conditions was extracted (value provided by Polar Pro Trainer software). A two independent Mann-Whitney U test was conducted with mean HR values as test variable and experimental condition (natural or neutral) as grouping variable. All statistical analyses were run in IBM SPSS (statistical analysis software).

Results

Hypothesis 1. Resting with a window view of a genuine natural environment after a physical stressor yields significantly shorter choice reaction times compared to resting without a view.

Individual data. Individual results from each subject are summarized in table 1. Nine out of ten subjects performed better in the CRT task after resting with a natural view, compared to a neutral. Two subjects (3, 5) performed worse than baseline after resting with a neutral view condition and one of these two (3) performed worse than baseline in both conditions. The biggest improvement was elicited by subject 10, who improved his mean CRT with 92 ms after the natural condition, compared to an improvement of 22 ms in the neutral condition. The biggest difference in improvement between the two conditions was elicited by subject 8, with a difference of 75 ms (neutral: 2 ms, natural: 77 ms).

Table 1. Sumary of each subject's choice reaction time (CRT) results. Experimental manipulations are highlighted. Values in cursive are in milliseconds

Choice reaction time results				
Subject	Post CRT mean, **neutral** condition	Post CRT mean **view** condition	Pre to post CRT improvement, **neutral** condition	Pre to post CRT improvement, **view** condition
1	*391*	*377*	*4*	*20*
2	*401*	*424*	*24*	*46*
3	*397*	*389*	*-13*	*-1*
4	*367*	*392*	*22*	*17*
5	*427*	*406*	*-3*	*18*
6	*428*	*370*	*21*	*23*
7	*421*	*393*	*17*	*52*
8	*428*	*419*	*2*	*77*
9	*395*	*378*	*24*	*29*
10	*374*	*368*	*20*	*92*

Group Data. Kendall's coefficient of concordance test revealed that choice reaction times (CRT) were significantly shorter after resting with a window view of a natural environment compared to resting with a neutral view [W=.52, χ^2=15.6, df=3,p<.05]. There was no significant difference between pre-test measures of CRT. Figure 6 illustrates the differences in mean CRT results.

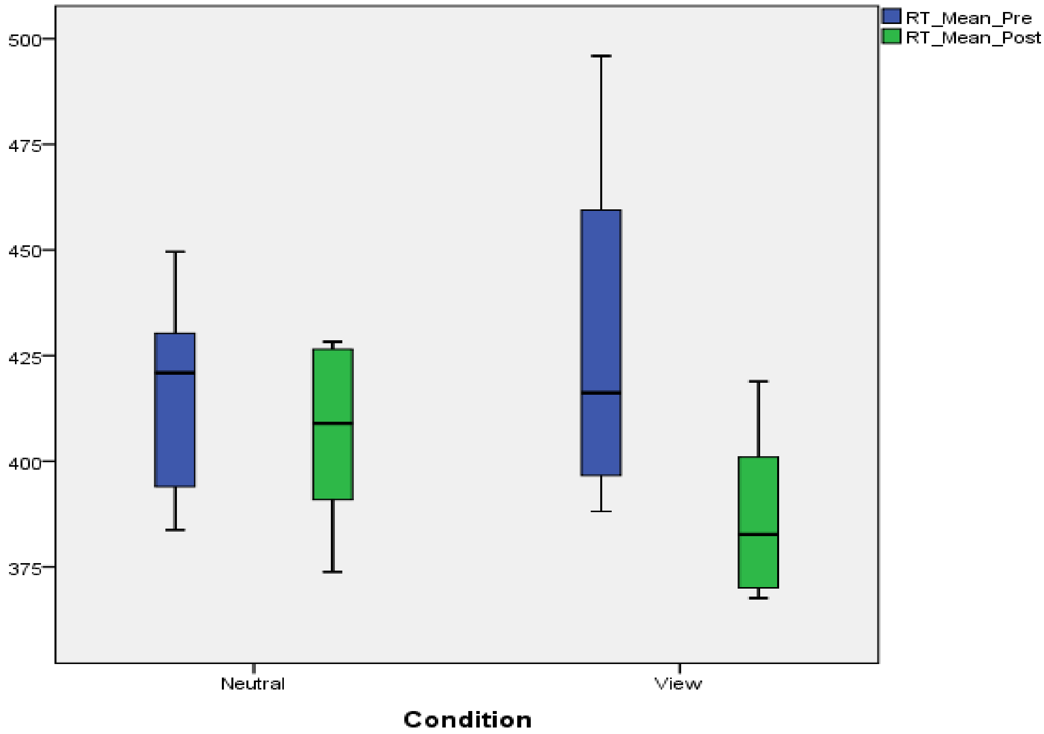

Figure 6. Illustration of the mean Choice Reaction Time (CRT) results in a box plot. Pre-test CRTs are shown in blue, and post-test CRTs are shown in green. The y-axis represents milliseconds from stimulus to response. The x-axis represents the experimental conditions (neutral view and view of natural environment).

Mean post reaction times were 391,83ms (*SD*=19.55) for the natural view condition, and 403,02ms (*SD*=22.10) for the neutral view condition. Resting with the natural view yielded a mean CRT improvement of 37,30 ms (*SD*=29.22), compared to a mean CRT improvement of 11,70 ms (*SD*=13.22) after resting without a view. Calculating percentage based on the mean pre-test results and mean improvement provides a 8,3% improvement for the natural view condition, and a 2,8% improvement for the neutral condition.

Hypothesis 2. Resting with a window view of a genuine natural environment after a physical stressor induces more efficient heart rate restoration compared to resting without a view.

Individual data. Subjects' individual heart rate restoration time results are summarized in table 2. Eight out of nine subjects elicited shorter restoration time in the natural condition, compared to the neutral condition. One subject (Nr.7) elicited shorter restoration time in the neutral condition (50 seconds), compared to the natural condition (52 seconds). The biggest difference in restoration time between the two conditions was elicited by subject 2, with a difference of 112 seconds (natural: 493 sec, neutral: 605 sec). This subject's values were abnormally large compared to the values of the other subjects. The mean restoration time for the nine other subjects were 32 seconds (*SD*=11) in the view condition, and 52 seconds (*SD*=19) in the neutral condition, which differs greatly from the values of subject 2. Hence, the values of subject 2 are outliers. However, outliers do not skew the results of the non-parametric analysis applied in the present study. Thus, exclusion from analysis is not necessary.

Table 2. Summary of each subject's heart rate restoration time. Experimental manipulations are highlighted. Values in cursive are in seconds.

	Heart rate restoration results									
Subject	1	2	3	4	5	6	7	8	9	10
*Restoration time, **natural** condition*	*36*	*493*	*26*	*28*	*35*	*	*52*	*14*	*39*	*27*
*Restoration time, **neutral** condition*	*86*	*605*	*62*	*35*	*68*	*	*50*	*44*	*41*	*31*

* An error occurred during measure of heart rate variability

Group Data. A Mann-Whitney U test revealed that resting with a window view of a genuine natural environment after a minor physical exertion yielded significantly more efficient heart rate restoration compared to resting without a view [U=18.5,Z=-1.94, df=1, p<.05]. The differences in mean restoration time are illustrated in figure 7.

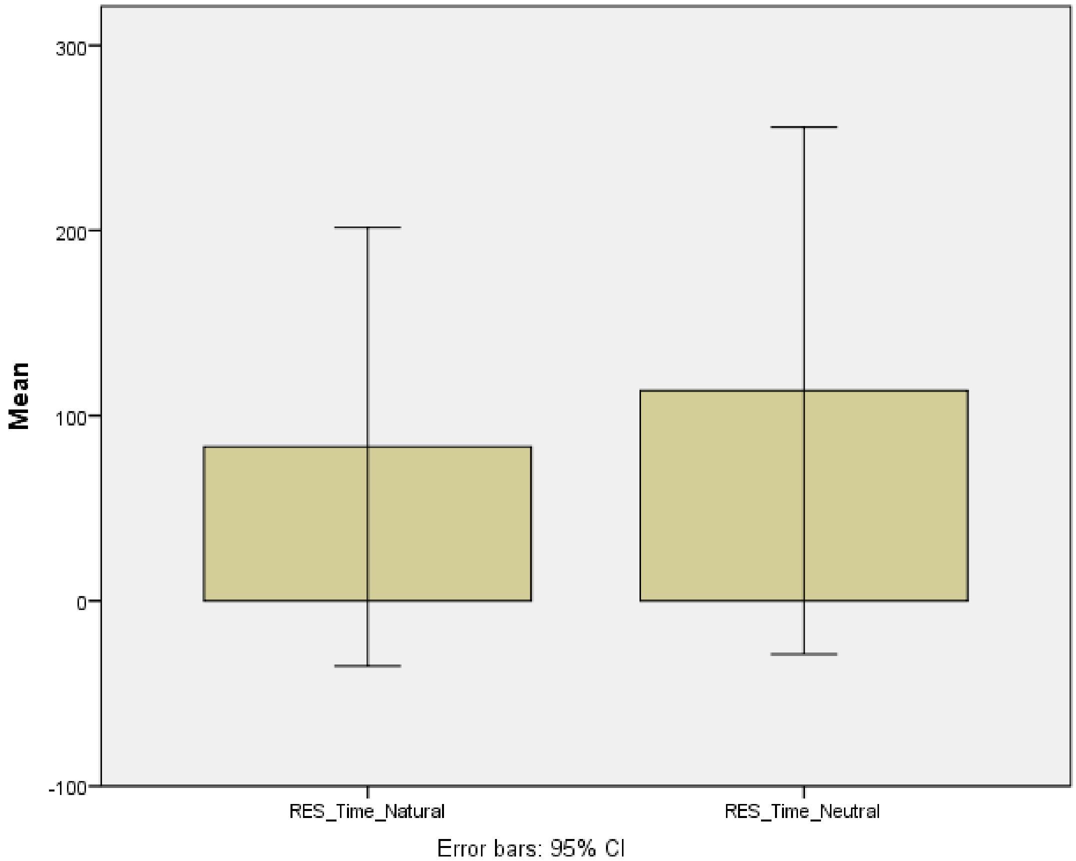

Figure 7. Illustration of the differences in restoration time between resting with a window view of a genuine natural environment (column to the left) and resting without a window view (column to the right).Y-axis represents restoration time in seconds and x-axis represents experimental condition (natural view and neutral view). Standard error are represented in the figure by the error bars attached to each column.

Mean restoration time of all subjects was 83 seconds (SD=154) in the natural view condition, and 114 seconds (SD=185) in the neutral condition. Hence, the natural view condition on average elicited 26,5% faster HR restoration compared to the neutral condition.

The outlying values of subject 2 have great influence on the means and deviations. Excluding this subject gives mean restoration times of 32 seconds (*SD*=11) in the view condition, and 52 seconds (*SD*=19) in the neutral condition. With the outlying subject excluded, the natural view condition elicited a 38,5% faster restoration time compared to the neutral condition.

Hypothesis 3. Subjects are expected to elicit lower mean heart rate during 10 minutes of rest with a view of a genuine natural environment, compared to resting without a view.

Individual data. Subjects' individual heart rate results are summarized in table 3. Six out of nine subjects elicited a lower mean heart rate (HR) in the natural condition. Three subjects (4, 7, 10) elicited their lowest mean HR in the neutral condition. Six out of nine subjects reached their lowest point of HR during the natural condition. Two subjects (4, 9) reached their lowest point of HR in the neutral condition. One subject (8) did not differ in lowest point of HR between the conditions.

Table 3. Summary of each subject's heart rate (HR) results. Experimental conditions are highlighted. Heart rate values are in cursive.

	Heart rate means and low points									
Subject	1	2	3	4	5	6	7	8	9	10
Mean HR during 10 min rest, **natural** condition	*75*	*105*	*65*	*73*	*70*	*	*68*	*44*	*75*	*66*
Mean HR during 10 min rest, **neutral** condition	*87*	*118*	*69*	*71*	*71*	*	*62*	*65*	*79*	*63*
Lowest HR during 10 min rest, **natural** condition	*65*	*88*	*55*	*60*	*59*	*45*	*35*	*66*	*54*	*48*
Lowest HR during 10 min rest, **neutral** condition	*81*	*99*	*57*	*55*	*61*	*52*	*54*	*66*	*53*	*59*

* An error occurred during measure of heart rate variability

Group data. No significant differences were found in mean HR during restoration period. However, there was a trend in favor of hypothesis 3. Subjects mean HR during the restoration period was 71 (*SD*=15,93) in the view condition, and 76 (*SD*=16,36) in the neutral condition. The differences in mean HR, including standard deviations, are illustrated in figure 7. Overall, subjects reached a lower point of HR in the view condition with a mean low point of 58 (*SD*=14,29), compared to a mean low point of 64 (*SD*=15,08) in the neutral condition. However, these differences were not statistically significant.

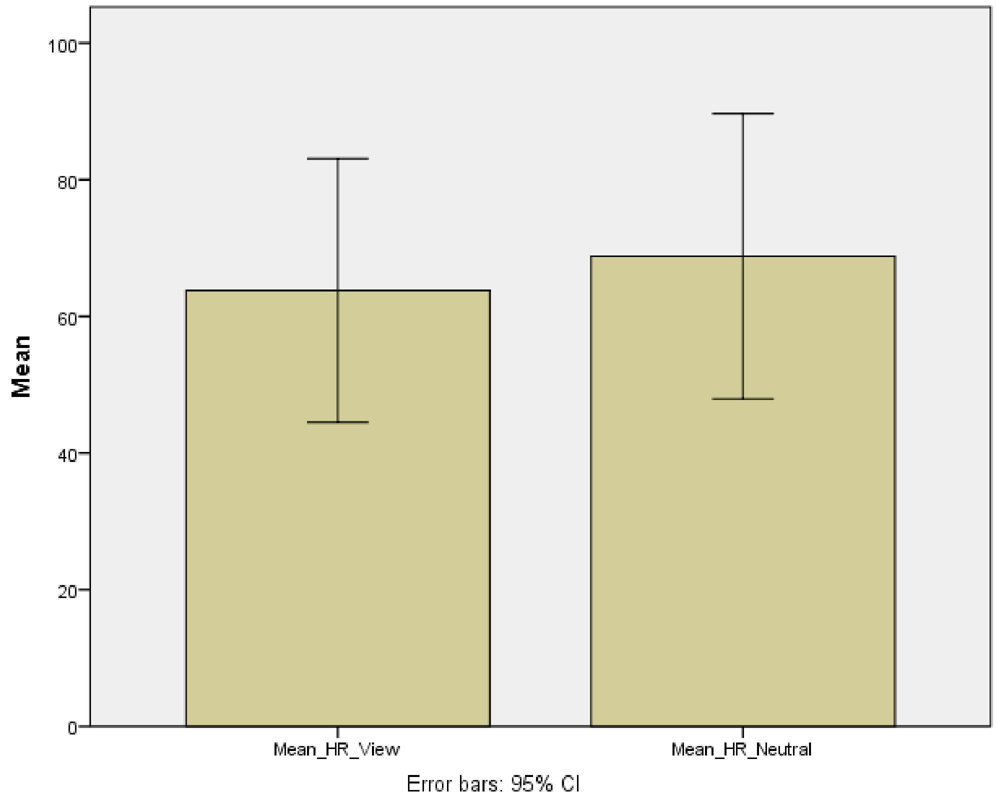

Figure 8. Illustration of the differences in mean heart rate (HR) during restoration period between resting with a window view of a genuine natural environment (column to the left) and resting without a window view (column to the right). Y-axis HR value and x-axis represents experimental condition (natural view and neutral view). Standard errors are represented in the figure by the error bars attached to each column.

Discussion

The aim of the present study was to investigate how resting with a window view of a natural environment after a physical stressor affects cognitive capacity and heart rate restoration. Psychophysiological measures were applied based on prior research (Lohr et al., 1996; Hartig et al., 2003; Laumann et al., 2003). Choice reaction time (CRT) performance, an indication of cognitive capacity, was measured before and after a minor physical exertion followed by 10 minutes of resting with either a window view of a natural environment (natural condition) or without a view (neutral condition). Heart rate variability (HRV) was also measured during the 10 minutes of rest, providing information about restoration time, average heart rate (HR) and lowest point of HR reached during restoration period.

The findings of this study are consistent with the first primary hypothesis, suggesting that resting with a window view of a genuine natural environment after a physical stressor yields significantly shorter CRTs than resting without a view. Post CRT performance was significantly better in the natural environment condition, indicative of an improved cognitive capacity (Salthouse, 1996; Madden, 2001; Jensen, 2006; Deary, Liewald & Nissan, 2010). HR restoration results were consistent with the second primary hypothesis, suggesting that resting with a window view of a genuine natural environment after a physical stressor induces more efficient heart rate restoration compared to resting without a view. Mean restoration time was significantly shorter when resting in the natural environment condition (83 seconds) compared to resting in the neutral condition (118 seconds).

Hypothesis 1. Resting with a window view of a genuine natural environment after a physical stressor yields significantly shorter choice reaction times compared to resting without a view.

Results from the present study are consistent with hypothesis 1 and in agreement with prior research, showing performance enhancement on cognitively demanding tasks as a function of the presence of natural environments (Tennessen & Cimprich, 1995; Lohr et al., 1996; Berto, 2005; Berman et al., 2008), and contradictive to the results regarding cognitive functioning in the studies by Laumann et al. (2003) and Larsen et al. (2008). Lohr et al. (1996) found a 12% improvement in CRT measures in their psychophysiological study, and the present study elicited an improvement of 8,2%. Lohr et al. applied the presence of interior plants as experimental manipulation during a CRT task, which differs with the present study's utilization of a window view of a natural environment. Thus, one should keep in mind that interior plants and a window view of nature are two separate experimental manipulations. However, the definition of natural environments stated by Hartig et al. (2011), emphasize that even the smallest features of nature can be experienced as a natural environment. Hence, the two studies are comparable to some degree, and both the study done by Lohr et al. (1996) and the present study provide solid implications suggesting that having features of nature in your surroundings can improve cognitive functioning.

The present study offers an interesting advancement of the results found by Lohr et al. (1996) regarding the post CRT measures. In contrast to Lohr et al., the post CRT task in the present study was not done in the presence of natural features. Rather, the post task was done without the presence of natural features, but after 10 minutes of rest with a view of a natural environment. Nevertheless, the results show that the natural environment improved CRT performance. This demonstrates that the effect of CRT improvement does not depend on natural features being present during performance; rather the performance enhancement is prominent even when there is no longer a view of nature. Prior studies have obtained similar results with the use of neutral post-test environments (Berto, 2005; Berman et al, 2008), but no studies to date except the present one, have obtained such results accompanied by significant restorative effects on autonomic arousal using the same sample and same manipulations.

The significantly more improved CRT performance in the present study is contradictive to the results from Laumann et al. (2003). In their study, simulated natural environments did not significantly improve performance on an attention oriented reaction time task, even though there was a significant restorative effect on autonomic arousal. Based on theories by Easterbrook (1959) and Eysenck (1982), Laumann et al. (2003) suggest that attentional selectivity confounded performance on their reaction time task, and that increased arousal will improve performance on tasks that do not require broad attentional selectivity. Hence, they suggest that the restorative effects of their nature simulations increased attentional selectivity and that the lack of significant post-test improvement after watching nature simulations might have been a result of the attention task not being attentionally demanding enough. Interestingly, the reaction time task in the present study is arguably no more attentionally demanding than the task utilized by Laumann et al. The reaction time task in the present study utilizes four different stimuli seeing as one type of stimulus (‘X’) might appear in one of four boxes in each trail (see figure 4). The attentionally demanding aspects of this task are the processes of detecting the appearing stimulus, and then responding by pressing the appropriate key as quickly as possible. Laumann et al. (2003) applied a reaction time task with 12 different stimuli demanding both detection of two different types of stimulus, processing of both valid and invalid cues, and response by pressing the appropriate key as quickly as possible. Based on this, one might view the task utilized by Laumann et al. as more attentionally demanding compared to the task utilized by the present study. Hence, the present study contradicts the ideas derived from theories by Easterbrook (1959) and Eysenck (1982), stating that increased autonomic arousal will transcend the restorative effects of natural environments on performance on tasks that do not require broad attentional selectivity.

Based on the study done by Kjellgren and Buhrkall (2010) demonstrating that genuine natural environments tend to be more restorative compared to simulated natural environments, the present paper suggested that the video simulations of natural environments applied by Laumann et al. (2003) might not have provided a sufficient experience of nature in order to induce cognitive restoration. In that regard, an explanation of why the present results differ from the results of Laumann et al. might be that the window view of a genuine natural environment in the present study was more cognitively restorative compared to a simulated natural environment. This explanation, however, would suggest that there is a lower threshold for nature inducing physiological restoration compared to cognitive restoration, seeing as Laumann et al. found significant restorative effects of nature on heart rate variability. One might speculate that this indicates that nature first induces physiologically restorative effects, and then physiological restoration leads to cognitively restorative effects, and not the other way around or a linear relationship. Meaning that the simulated natural environments had a physiologically restorative effect on the subjects in Laumann et al.'s study, but the environment was not sufficiently restorative enough for the induced physiological effects to have an influence on cognitive functioning. However, studies more fixated on the relative timing between physiological and cognitive effects of restoration would be necessary to investigate these speculations further.

Hartig et al. (2003) did not obtain significant improvements in cognitive capacity in their extensive psychophysiological experiment, but there was a mild trend of performance enhancement in the natural conditions. A part of their experiment involved resting in a chair for 10 minutes with or without a window view of a natural environmet. These experimental manipulations were adopted by the present study. However, Hartig et al. did not apply measures of attention capacity (AC) immediately after the seated restoration period. Rather, they applied the post-test of AC after the natural and urban walks. A significant decrease in subjects' blood pressure (BP) were found after both 4 minutes and 10 minutes of resting with a window view compared to non view, but these differences were evened out after the end of the natural and urban walks. Based on the results from the present study, Hartig et al. might have obtained larger differences in AC performance if they had applied a post AC test immediately after the 10 minutes of seated rest. The total duration of their experiment is not precisely specified, but the experiment lasted at least several hours, including a 40-45 minutes long drive, an hour long mental loading task (for the task groups), 50 minutes of walking and additional minutes spent doing AC and BP measures. It is difficult to disregard that the extensiveness and duration of the experiment might have influenced the subjects, especially with regards to the measures taken later in the procedure. The results of BP measures evening out at the end of the natural and urban walks might be a reflection of subject tiredness, and the significant decrease in BP after four and 10 minutes of resting with a natural view might have been accompanied by a larger improvement in AC measures, had the measures been taken before BP started to even out. This becomes even more probable when you consider the emotional measures in the experiment which showed that subjects, except the subjects in the natural condition who did not do the hour long mental loading tasks, reported increased anger at the end of the experiment. However, the no-task nature group did overall report more positive emotions, indicating that the natural environment had positive effects on mood regardless of the moderate AC results (Hartig et al., 2003).

Hypothesis 2. Resting with a window view of a genuine natural environment after a physical stressor induces more efficient heart rate restoration compared to resting without a view.

The second primary hypothesis was exploratory, and the measures provided interesting results in support of the hypothesis. As illustrated in figure 7, resting with a window view of a genuine natural environment after a minor physical stressor yielded significantly shorter heart rate (HR) restoration times, compared to resting in a neutral environment. HR restoration was 26,5% faster in the natural condition. Prior research applying physiological measures to study restorative effects have mainly been concerned with the average level of physical arousal during a prolonged period of experimental manipulations (Ulrich, 1981; Parsons, 1998; Hartig et al., 2003; Laumann et al., 2003; Ulrich, 2003). Hence, the present study provides novel implications regarding restorative effects of natural environments after a physical stressor. A noteworthy aspect of these results is that there was a significant difference in restoration time in the two conditions, even though the average restoration times were only 32 seconds (*SD*=11) in the view condition and 52 seconds in the neutral condition (*SD*=19) (outlying values of subject 2 excluded). This is indicative of an immediate restorative effect induced by the view of nature, and these results provide advancing insight into the temporal characteristics of the restorative effects of natural environments.

Hypothesis 3. Subjects are expected to elicit lower mean heart rate during 10 minutes of rest with a view of a genuine natural environment, compared to resting without a view.

Average HR during the 10 minutes restoration period was not significantly lower in the natural environment condition, thus, inconsistent with hypothesis 3. However, as illustrated in figure 8, there was a mild trend in support of the hypothesis. Given the relatively modest sample size, this mild trend should not be interpreted as consistent with prior research showing a decrease in average autonomic arousal in natural environments (Ulrich, 1981; Parsons, 1998; Hartig et al., 2003; Laumann et al., 2003).

The average HR results in the present study are quite interesting when HR restoration time results are also considered. As shown in figure 7, HR restoration time was significantly shorter with a view of nature, and the mean restoration times were 32 seconds (*SD*=11) and 52 seconds (*SD*=19) (outlying values of subject 2 excluded) indicating more parasympathetic tone during the first minute of rest (Arai et al., 1989; Imai et al., 1994; Ohuchi, 2000; Dogru et al., 2007). Considering those results, it is likely that the mild trend of the natural condition eliciting a lower average HR is mainly due to the differences in HR the first few minutes. But, as in the results obtained by Hartig et al. (2003), these differences were eventually evened out. These considerations combined with the present results, and the results obtained by Hartig et al. might indicate that the critical aspects of the restorative effects from natural environments are linked to the immediate shifts in a person's autonomic balance. Meaning, the restorative effects of nature are most influential during the process of autonomic shift from sympathetic to parasympathetic activation, and the following rapid increase in parasympathetic tone. Although the present study provides some indications supporting this, it is merely speculative. In order to further investigate the relationship between autonomic balance and restoration in natural environments, employing additional parameters of autonomic arousal in a similar experiment would be beneficial. Especially, blood samples in order to measure catecholamine levels combined with HRV measures might provide a more nuanced measure of parasympathetic tone. In addition, seeing as the difference in autonomic arousal might be at its most evident during the first minutes of restoration, perhaps this implicates that the cognitive restoration would also be most prominent during this period. A way of testing this would be to apply a cognitive measure one or two minutes into restoration and see if the effects are already present, and compare them to measures taken after several minutes of restoration. This might also provide implications regarding causality between physiologically and cognitively restorative effects, as discussed above.

Attention Restoration Theory

The present study offers support to several notions in the attention restoration theory (ART) (Kaplan & Kaplan, 1989; Kaplan, 1995). First and foremost, the significant difference in improvement in CRTs after resting with a genuine view of a natural environment, compared to a neutral view, implicate that the natural environments induce performance enhancement on an attention demanding task. In interpreting these results in terms of ART, one might suggest that the window view of the forest dominated hillside and field land induced a ‘cognitive breather’, allowing the ability to direct attention to be restored. This in turn improved the ability to focus on the task at hand during post CRT task, thus, improved performance significantly more than resting without a natural view. Second, the difference in improvement was present even though the subjects were only told to rest and no instructions regarding where to look or where to focus was given. This is consistent with ART by implicating that the process of cognitive restoration was effortless. Third, the present study provides implications of a prolonged restorative effect induced on cognitive capacity that is still prominent even when there is no longer a view of nature. This supports the notion in ART (Kaplan, 1995) stating that restorative effects on cognitive capacity are still present in situations where natural features are absent. Last, regarding the four characteristic properties that Kaplan (1995) view as important for an environment to be restorative (fascination, being away, extent, compatibility), the present study did not intend to investigate the properties' validity in any way. The properties are not measured, but the modesty of the natural environment used in the present study suggests that it would not correlate highly on either fascination, being away, extent or compatibility, compared to representation of more scenic and spectacular nature used in prior research (Chang et al., 2008; Laumann et al., 2003; Berto, 2005). However, one can assume that the window view of natural environment in the present study would correlate more with the four properties, compared to the neutral view of an interior wall. Thus, both the significantly larger improvement in CRTs and significantly shorter restoration times in the natural condition demonstrate that fairly modest natural environments can induce positive psychophysiologically restorative effects, and not only environments highly compatible with the four properties of ART. Advantages in external validity will be discussed later in that regard.

Biophilia Theory

The restorative effects on HR in the present study can be interpreted as support of the biophilia theory (BT) (Ulrich et al., 1991; Ulrich 1993). BT states that natural environments induce stress reduction through decrease in autonomic arousal. Decrease in autonomic arousal indicates an increase in parasympathetic activity (Freeman et al., 2006; Dogru et al., 2007), and heart rate restoration (HRR) during the few minutes immediately after physical activity have been identified as a good marker of parasympathetic activity (Arai et al., 1989; Ohuchi et al., 2000). Hence, the results from the present study yielding a 26,5% more efficient HRR in the natural environment indicate a stronger parasympathetic tone, which can in line with the BT be interpreted as inducing faster stress reduction. In terms of the BT, the more efficient HRR might be a result of innate affective biophilic responses inducing a reduction of autonomic arousal during rest with a view of a natural environment.

Strengths and limitations

The present study recognize limitations regarding the fairly modest sample size (N=10), suggesting that one should take precautions before generalizing on the basis of the present results. However, the within-subjects design increases the reliability of the results.

The present study utilizes a window view of genuine natural environment and a no view environment with an ordinary interior wall as experimental manipulations. This offers both advantages and limitations. Prior research in the current field often use artificial representations of environments, such as photos or videos, as manipulations (Chang et al., 2008; Laumann et al., 2003; Berto, 2005; Berman et al., 2008). Compared to a genuine environment, this limits the amount of potential confounds, such as weather variables. The weather was quite similar in all sessions in the present study. During six of the 10 session, the weather was overcast. In all sessions, the field land and forest was fully or partially covered in snow. Two sessions had a moderate amount of precipitation, and two sessions were partially cloudy with sunlight. Neither the precipitation sessions nor the sunny sessions elicited CRT measures or HR measures deviating substantially more than the standard deviations. However, the modest sample size in the present study makes the weather conditions difficult to control for.

The genuine natural environment used as experimental manipulation offer advantages regarding external validity. Genuine natural environments have been shown to be more restorative compared to artificial natural environments (Kjellgren & Buhrkall, 2010). Hence, the utilization of a window view of a forest dominated hillside and field land provides a highly valid representation of nature. In addition, using a window view instead of conducting experiments outside limits the amount of potential confounds. An interesting aspect of the present study is the utilization of a fairly moderate natural environment with significant effects on cognitive performance. Prior research employing cognitive measures to investigate restorative effects of natural environments tend to utilize grand representations of scenic and beautiful nature as experimental stimulus and manipulations (Laumann et al., 2003; Berto, 2005). As shown in figure 2, the present study utilized the view of a forest dominated hillside and field land, located near a university. This is no spectacular view. It is a fairly regular sight for a Norwegian, seeing as similar environments are located all over the Norwegian countryside. Nevertheless, the environment is clearly dominated by natural features. The genuineness and modesty of the natural view substantially improve the external validity of the present study, and it demonstrates that even modest natural environments may have significant effects on cognitive functioning and autonomic arousal.

A limitation regarding the environmental manipulations used is the relative lack of compatibility between the neutral non-view environment and the natural view environment. The natural environment is richer on information and stimuli compared to the plain and information-poor non-view environment. Including a window view of a genuine non-natural environment (e.g. urban environment) as a third experimental manipulation would add another dimension to the experiment and increase validity.

Choice reaction times are reliable measures of cognitive processing speed (Salthouse, 1996; Madden, 2001; Jensen, 2006; Deary et al., 2010). The Deary-Liewald choice reaction time task used in the present research is free, easy-used, and standardized. Hence, the CRT measures in the present study can easily be replicated.

Regarding the HRV measures, some limitations should be mentioned. The analysis procedure of using the average peak inter-beat interval (IBI) and the 50% increase of average peak IBI as reference points for restoration time was used with the intentions of minimizing the influence of individual differences in cardiovascular fitness. This method of analysis is new and exploratory, thus, one should naturally question its reliability. However, the procedure ensured that the subjects had the same percentage increase in heart rate during activity, and IBIs in the precision of milliseconds were used to calculate two reference points with the exact same percentage of decrease in IBI between them (50%) in order to calculate restoration time. Hence, the present study views these measures as precise, reliable and possible to replicate.

Implications

A restored cognitive capacity is beneficial for everyday functionality and coping (Kaplan, 1995). The natural window view eliciting performance enhancement on cognitively demanding tasks, and more efficient stress reduction, provide implications of value from both an educational and work related perspective. From a health perspective, improved cognitive functioning can aid the process of coping with severe illness (Cimprich, 1993; Valentine & Meyers, 2001; Lawrence et al, 2004). The occurrence of stress-related illness such as burnout-syndrome, chronic fatigue, anxiety and depression has rapidly increased in western societies the last decades (Ekman & Arnetz, 2005). Effects of stress reduction may play a preventive role against such illnesses (World Health Organization, 2001), in addition to cardiovascular, autoimmune and infectious diseases often exacerbated by immune suppression (Sapolsky, 1998; McEwen, 2001). Implications regarding the value of implementing features of nature in the architecture and design of hospitals, rehabilitation centers, schools, office buildings, urban parks, roads and streets should be considered in the light of the present, and prior, research. With the rapidly increasing urbanization, the restorative and recreational potentials of nature grow even bigger. Inner city-, or close to city-, recreational environments can have a positive influence on populations' general health and well being.

This field of research is currently taking important steps towards gaining more knowledge concerning potential restorativeness of specific features of nature, in order to achieve a better understanding of which features of nature we should implement in our surroundings, and how (Joye, 2007; Nordh et al., 2009; Lindal & Hartig, 2012). However, the present study would like to emphasize the importance of gaining a broader understanding of the underlying mechanisms responsible for the restorative effects of nature: More precise and concrete knowledge about these mechanisms would provide a more solid foundation to develop measures upon. Additionally, this could make knowledge from this field of reserach even more compelling, beneficial in the process of transitioning knowledge from research to utilization.

As mentioned above, a further development of the present study with the inclusion of blood samples measuring hormone levels could provide more precise indications of parasympathetic tone. Including a third non-natural window view manipulation could also be beneficial. Additionally applying MEG (Magnetoencephalograpfy) measures of the amygdala, and other relevant brain regions, could enable interesting comparisons of neural activation, hormone levels and HRV. A different experiment could apply stimuli of different types of simulated environments (including natural environments), fMRI (functional Magnetic Resonance Imaging), blood samples, and HRV measures to more precisely investigate potential relationships between neural activity, hormone secretion from the adrenal cortex and autonomic arousal. Perhaps one would discover relationships between stimuli of natural environments, a specific activation in the amygdala (or another brain region) and the inhibition of catecholamine secretion (or other hormonal responses), leading to increased parasympathetic activity and reduced heart rate.

Concluding remarks

Numerous studies have demonstrated that natural environments may either improve cognitive functioning or reduce autonomic arousal. The present research advances prior research by demonstrating that resting with a fairly modest view of a natural environment can induce both cognitive and physiological effects beneficial from both health and performance perspectives. Just 10 minutes of resting with a window view of a natural environment yielded substantially larger improvements in cognitive functioning compared to resting without a view. The same window view also induced significantly more effective heart rate restoration after a physical stressor. In light of the present and prior research, the health-, work-, and educationally-related values of implementing features of nature in the rapidly increasing urban development should not be underestimated. Rather, it should be made common knowledge and more present in architectural and interventional considerations.

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Appendix

Appendix A

Table 1

Choice reaction time results

Subject	Post CRT mean, **neutral** condition	Post CRT mean **view** condition	Pre to post CRT improvement, **neutral** condition	Pre to post CRT improvement, **view** condition
1	*391*	*377*	*4*	*20*
2	*401*	*424*	*24*	*46*
3	*397*	*389*	*-13*	*-1*
4	*367*	*392*	*22*	*17*
5	*427*	*406*	*-3*	*18*
6	*428*	*370*	*21*	*23*
7	*421*	*393*	*17*	*52*
8	*428*	*419*	*2*	*77*
9	*395*	*378*	*24*	*29*
10	*374*	*368*	*20*	*92*

Appendix B

Table 2

	Heart rate restoration results									
Subject	1	2	3	4	5	6	7	8	9	10
*Restoration time, **natural** condition*	*36*	*493*	*26*	*28*	*35*	*	*52*	*14*	*39*	*27*
*Restoration time, **neutral** condition*	*86*	*605*	*62*	*35*	*68*	*	*50*	*44*	*41*	*31*

* An error occurred during measure of heart rate variability

Appendix C

Table 3

	Heart rate means and low points									
Subject	1	2	3	4	5	6	7	8	9	10
*Mean HR during 10 min rest, **natural** condition*	*75*	*105*	*65*	*73*	*70*	*	*68*	*44*	*75*	*66*
*Mean HR during 10 min rest, **neutral** condition*	*87*	*118*	*69*	*71*	*71*	*	*62*	*65*	*79*	*63*
*Lowest HR during 10 min rest, **natural** condition*	*65*	*88*	*55*	*60*	*59*	*45*	*35*	*66*	*54*	*48*
*Lowest HR during 10 min rest, **neutral** condition*	*81*	*99*	*57*	*55*	*61*	*52*	*54*	*66*	*53*	*59*

Appendix D

Figure 1

	Experimental design				
	Step 1	Step 2	Step 3	Step 4	Step 5
Session 1	Questionnaire	Reaction time pre-test	Cycling 5 min	Rest in **View/neutral** environment 10 min, 30 sec	Reaction time post-test
Session 2	Questionnaire	Reaction time pre-test	Cycling 5 min	Rest in **Neutral/view** environment 10 min, 30 sec	Reaction time post-test

Appendix E

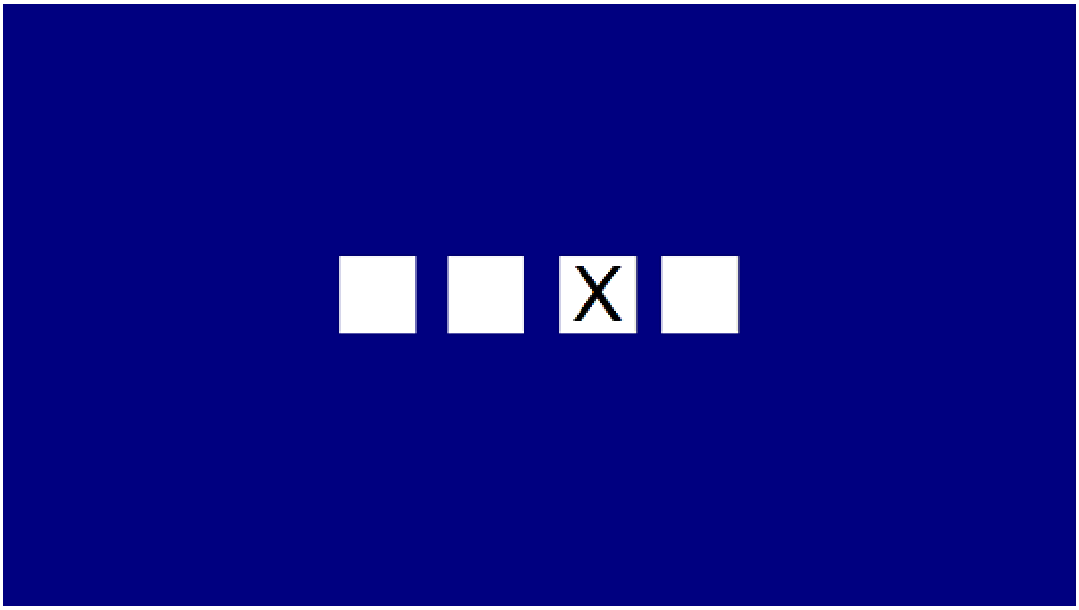
Figure 2

Appendix F

Figure 3

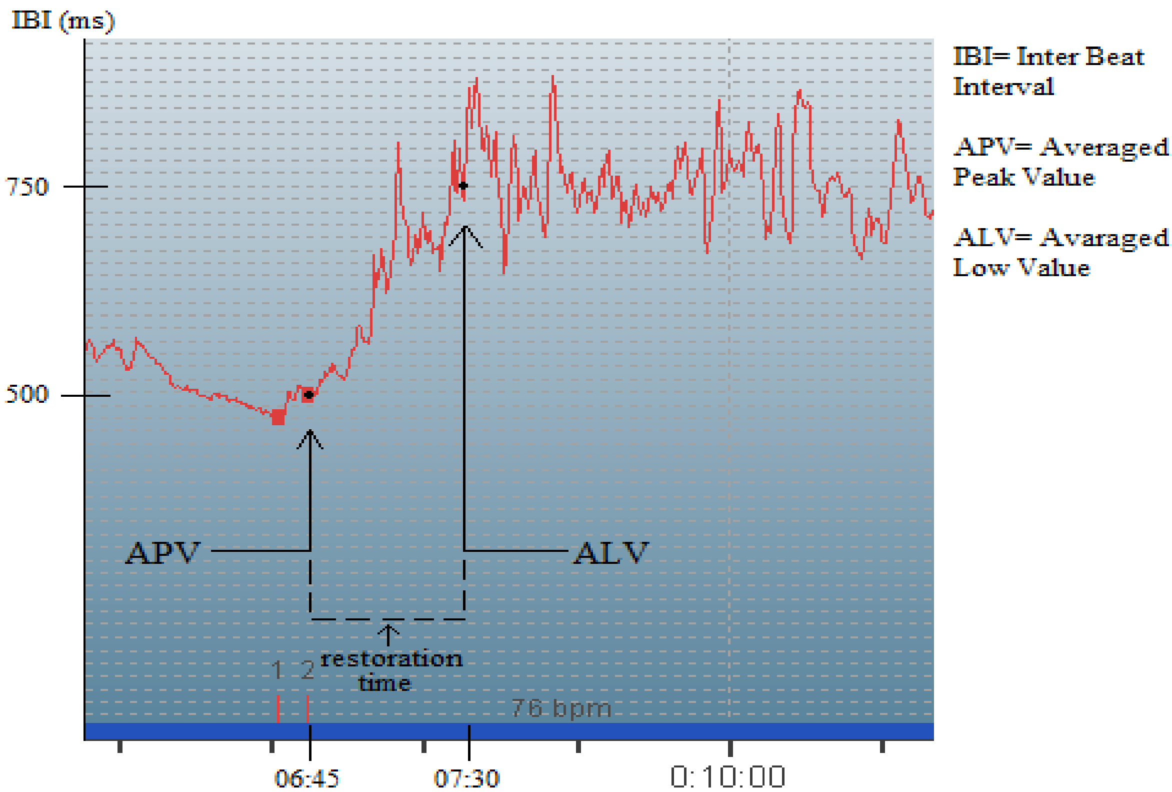
Appendix G

Figure 4



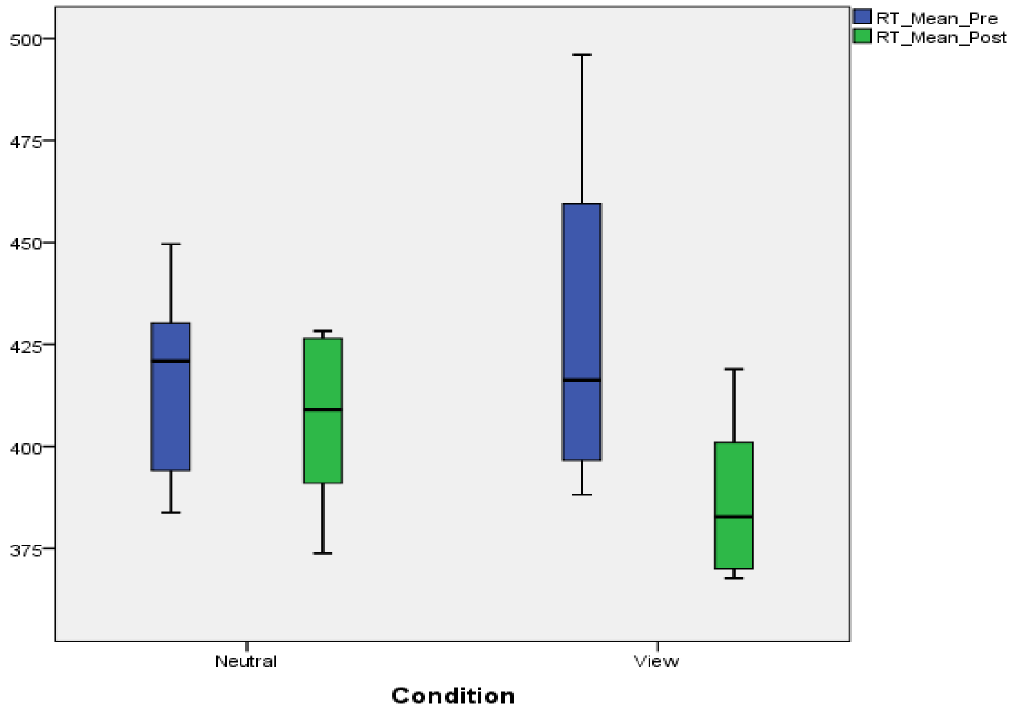
Appendix H

Figure 5



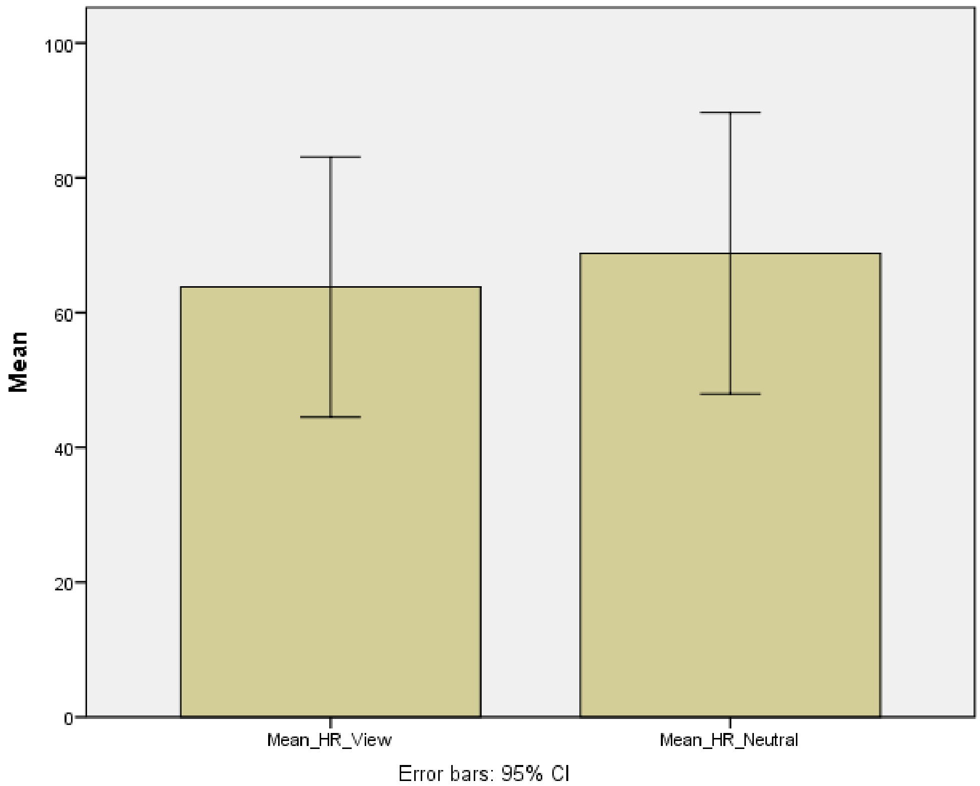
Appendix I

Figure 6



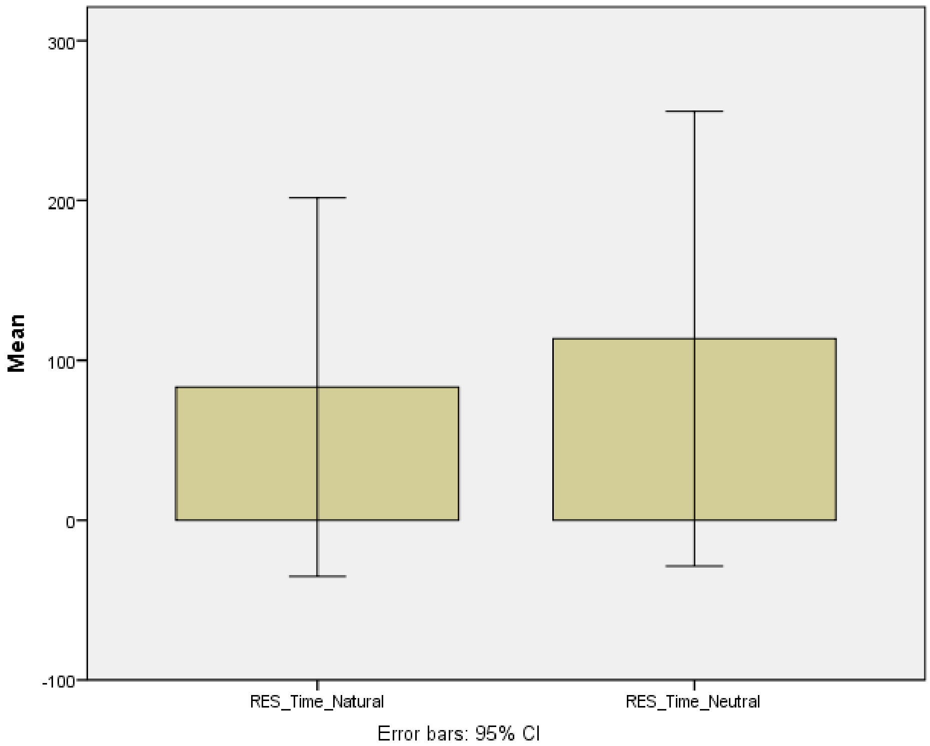
Appendix J

Figure 7



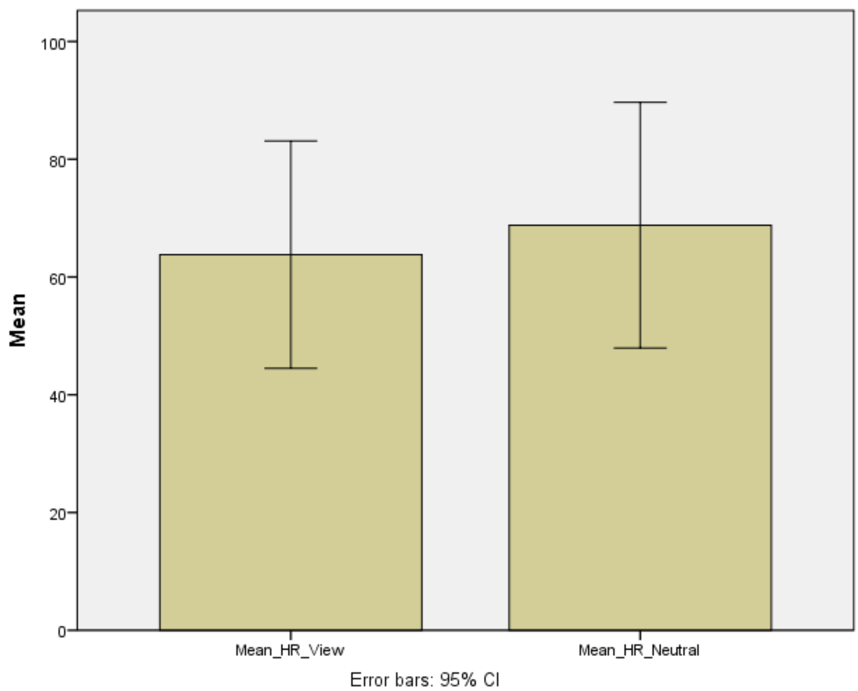
Appendix K

Figure 8



Appendix L

Figure 9



Appendix M

Information and consent form

Informasjonsskriv og samtykkeskjema

Fysiologisk og kognitiv restitusjon
Høst/vinter 2012/2013

Norges teknisk-naturvitenskapelig universitet
Psykologisk institutt, NTNU
7491 Trondheim

Forespørsel om deltakelse i forskningsprosjekt: **Fysiologisk og kognitiv restitusjon fra lett fysisk aktivitet**

Studien vil undersøke hvordan fysiologisk og kognitiv restitusjon fra mild fysisk aktivitet påvirkes av forskjellige omgivelser. Eksperimentet består av å utfylle et kort spørreskjema, gjennomføre en kort oppmerksomhetstest, fem minutter med sykling på ergometersykkel, 10 minutter hvile i en lenestol og en ny kort oppmerksomhetstest. Eksperimentet gjentas en gang én til syv dager etter.

Oppmerksomhetstesten foregår på en dataskjerm. Skjermen vil vise fire ruter og deltakeren vil ha et tastatur med fire knapper hvor hver knapp representerer hver sin rute. Det vil dukke opp et kryss i en av rutene, og deltakeren vil trykke på den knappen som representerer ruten med kryss i så fort som mulig. Testen tar ca 3 minutter.

Deltakeren vil ha på seg et pulsbelte og sykle på ergometersykkelen innendørs i fem få minutter, så vil deltakeren sette seg i en stol for å hvile ytterligere 10 minutter.

Studiets utvalg vil bestå av ca 12 studenter fra NTNU med lignende idrettslig bakgrunn. Eksperimentet vil finne sted på Dragvoll Idrettssenter i Trondheim. Total varighet av eksperimentet er beregnet til ca 20 minutter.

Prosjektet er basert på frivillig deltakelse, og man kan når som helst trekke seg underveis og be om å få data slettet uten begrunnelse. Man er ikke forpliktet til å gjennomføre, og en eventuell avbrytning vil ikke få noen konsekvenser. Dataene fra eksperimentet vil benyttes i en forskningsartikkel som vil bli vurdert for publisering. Alle data som samles inn vil bli behandlet konfidensielt. Når prosjektet avsluttes våren 2013 vil all informasjon som kan knyttes til deltakerne bli makulert (kontaktinformasjon som e-postadresser etc). Annen informasjon som vil bli beholdt i form av data fra eksperimentet vil ikke kunne føres tilbake til forsøksperson.

Eventuelle spørsmål og henvendelser kan rettes til Hermundur Sigmundsson eller Thomas Engell.

Prosjektansvarlig:
Thomas Engell
Epost: Thomen@stud.ntnu.no

Faglig ansvarlig:
Hermundur Sigmundsson
Epost: Hermundur.Sigmundsson@svt.ntnu.no

SAMTYKKEERKLÆRING

Prosjekttittel: Fysiologisk og kognitiv restitusjon fra lett fysisk aktivitet

Jeg har lest informasjonsskrivet og jeg har hatt mulighet til å stille spørsmål angående min deltakelse i eksperimentet. Jeg sier meg villig til å delta i prosjektet.

……………………….. ………………… …………………………………….

Sted Dato Underskrift

Prosjektansvarlig:
Thomas Engell
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Faglig ansvarlig:
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Epost: Hermundur.Sigmundsson@svt.ntnu.no

Appendix N

Questionaire

Fysiologisk og kognitiv restitusjon fra mild fysisk aktivitet
Høst/vinter 2012/2013

Spørreskjema

Deltagerkode ________________

Dato ___________________

Tester ___________________

Informasjonen som samles i dette spørreskjema vil bli behandlet konfidensielt. Svarene her vil bli koblet til resultatene dine i eksperimentet, men ikke til ditt navn eller annen identifiserende informasjon. Informasjonen skal kun brukes for å forstå resultatene fra eksperimentet bedre. Når prosjektet avsluttes våren 2013 vil informasjonen fra spørreskjemaene bli makulert.

For å svare på spørsmålene nedenfor, vennligst kryss av/skriv tydelig.

1. Kjønn ______

2. Alder_______

3. Er du plaget av noen form for sykdom idag?

   Nei___
   Forkjølelse_____
   Allergi_____
   Influensa_____
   Hodepine_____
   Annet_________________________

4. Har du drukket kaffe eller andre koffeininnholdige drikker innen de siste tre timene?

   Ja___ Nei___

Prosjektansvarlig:
Thomas Engell
Epost: Thomen@stud.ntnu.no

Faglig ansvarlig:
Hermundur Sigmundsson
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5. Føler du at du har hatt tilstrekkelig med søvn i natt, normalt for deg?
   Ja____ Nei____

6. Har du drukket alkohol i løpet av de siste 24 timene? Ja____ Nei____

7. Har du tatt medikamenter eller substanser de siste 24 timene som kan påvirke din fysiske eller psykiske tilstand (Sovemedisiner, antidepressive, cannabis etc)?
   Ja____ Nei____

8. Har du noen helsehistorikk som kan påvirke din oppmerksomhet eller ditt syn i dag (hjernerystelse siste 6 mnd, epilepsi, ADHD etc)?

   Ja____ Nei____

9. Har du trent mer enn normalt denne uken?
   Ja____Nei_____

10. Føler du deg opplagt?
    Ja___Nei_____
    Hvis nei, hvorfor ikke? ______________________________________

Prosjektansvarlig:
Thomas Engell
Epost: Thomen@stud.ntnu.no

Faglig ansvarlig:
Hermundur Sigmundsson
Epost: Hermundur.Sigmundsson@svt.ntnu.no

Appendix O

Experimental procedure

Fysiologisk og kognitiv restitusjon fra mild fysisk aktivitet
Høst/vinter 2012/2013
Prosedyre

Forberedelse:

- Klargjør spinningsalen:
  - Luft rommet
  - Sett frem bord, stol og sykkel ca midt i rommet
  - Plasser stol enten mot veggen eller mot utsikt
  - Senk persiennene
  - Sørg for at det er nok lys

- Klargjør utstyr:

  - Sjekk at klokke fungerer
  - Sjekk at klokken er stilt inn på RR-data
  - Sjekk at pulsbeltet funker
  - Klargjør datamaskin for RT-test: Tørk støv av skjerm, vask tastatur
  - Sjekk at WindLink fungerer
  - Ha kalkulator og stoppeklokke klar på bordet

- Noter deltakerkoding og værforhold
  - Deltakerkode
  - Kodemail
  - Lag ny person på polarProtrainer (eks: 1.DeGea)
  - Dato og Tid
  - Sollys
  - Skydekke
  - Snømengde
  - Nedbør

Eksperiment

- Ta imot deltaker
  - Informasjonsskriv på bordet i salen
  - Informer om hva som skal skje
  - Fest på pulsbelte, fukte sensoren litt først med lunket vann.
  - Test pulsbelte når det er på
  - Sjekk at Windlink funker
  - Fest klokken på deltaker
  - Still inn høyde og motstand på sykkel

- Kjør eksperiment
  - Gjør klar RT-test, gå ut av rommet, si at deltakeren kan komme ut når testen er fullført
  - La deltakeren hvile på sykkelen i to minutter
  - Start klokken og noter hjerteraten
  - Deltakeren begynner å sykle
  - Regn ut 60% økning i hjerterate
  - Sørg for at deltaker overstiger 60% økning etter fem minutter sykling ved å følge med på windlink og gi instruksjoner angående intensitet
  - Hvis view-omgivelse, ta opp persiennene litt før de fem minuttene har gått
  - Etter fem min, deltaker flytter seg over i stolen.
  - Trykk new lap på dataen og start stoppeklokke, gå ut av rommet innen 15 sec
  - Gå inn i rommet etter 10 min og trykk på stopp.
  - Deltaker setter seg ved bordet og kjører post RT-test.

- Debrief
  - Avtal retest
  - Gi deltager en kodelapp for å enkelt identifisere datasett anonymt på retest
  - Etter at begge sesjonene er gjennomført: Spør om vedkommende vil ha mer info og eventuelt kopi av artikkel.
  - Gi en stor takk for deltakelsen

- Behandle resultater
  - Lagre Polar ProTrainer fil på minnepenn.
  - Lagre output fra RT-test på minnepenn. (eks: 1.DeGea.Nature)
  - Slett resultater fra dataen
  - Lås inn informasjonsskriv, mailingkodeark, minnepenn og klokker i safe.

Prosjektansvarlig:
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Epost: Thomen@stud.ntnu.no

Faglig ansvarlig:
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Epost: Hermundur.Sigmundsson@svt.ntnu.no

Appendix P

Approval from Norwegian Social Sciences Data Service (NSD). Part one

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

Harald Hårfagres gate 29
N-5007 Bergen
Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr. 985 321 884

Hermundur Sigmundsson
Psykologisk institutt
NTNU
7491 TRONDHEIM

Vår dato: 23.10.2012 Vår ref:31852 / 3 / MAS Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 17.10.2012. Meldingen gjelder prosjektet:

31852	*The Restoring Effects of Resting in Natural Environments*
Behandlingsansvarlig	*NTNU, ved institusjonens øverste leder*
Daglig ansvarlig	*Hermundur Sigmundsson*
Student	*Thomas Engell*

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, eventuelle kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/forsk_stud/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://pvo.nsd.no/prosjekt.

Personvernombudet vil ved prosjektets avslutning, 31.05.2013, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Vigdis Namtvedt Kvalheim

Mads Solberg

Kontaktperson: Mads Solberg tlf: 55 58 89 28
Vedlegg: Prosjektvurdering
Kopi: Thomas Engell, Brøsetveien 155 leil 25, 7050 TRONDHEIM

Avdelingskontorer / District Offices:
OSLO: NSD. Universitetet i Oslo, Postboks 1055 Blindern, 0316 Oslo. Tel: +47-22 85 52 11. nsd@uio.no
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Appendix Q

Approval from Norwegian Social Sciences Data Service (NSD). Part two

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 31852

Prosjektet skal undersøke effekten av fysisk hvile og resititusjon i naturomgivelser med indikatorer som hjerterate og beslutningstid.

Utvalget består av minimum 8 spillere ved NTNUIs innebandylag som rekrutteres av studenten gjennom formidling av informasjonsskriv.

Ifølge prosjektmeldingen skal det innhentes skriftlig samtykke basert på muntlig og skriftlig informasjon om prosjektet og behandling av personopplysninger. Personvernombudet finner informasjonsskrivet tilfredsstillende utformet i henhold til personopplysningslovens vilkår.

Det vil i prosjektet bli registrert sensitive personopplysninger om helseforhold, jf. personopplysningsloven § 2 nr. 8 c).

Prosjektet skal avsluttes 15.06.2013 og innsamlede opplysninger skal da anonymiseres. Anonymisering innebærer at direkte personidentifiserende opplysninger som navn/koblingsnøkkel slettes, og at indirekte personidentifiserende opplysninger (sammenstilling av bakgrunnsopplysninger som f.eks. yrke, alder, kjønn) fjernes eller grovkategoriseres slik at ingen enkeltpersoner kan gjenkjennes i materialet.