Ane Oline Roland

Effects of Acute Physical Activity on Sustained Attention

The Possible Influence of Natural Environments

Master's thesis in Learning - Brain, Behavior, Environment
Supervisor: Hermundur Sigmundsson
Trondheim, May 2017

Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Social and Educational Sciences
Department of Psychology

NTNU
Norwegian University of Science and Technology

NTNU
Norwegian University of Science and Technology

Ane Oline Roland

Effects of Acute Physical Activity on Sustained Attention

The Possible Influence of Natural Environments

Master's thesis in Learning - Brain, Behavior, Environment
Supervisor: Hermundur Sigmundsson
Trondheim, May 2017

Norwegian University of Science and Technology
Faculty of Social and Educational Sciences
Department of Psychology

NTNU
Norwegian University of
Science and Technology

Preface and Acknowledgements

The present work was carried out at the Department of Psychology, Norwegian University of Science and Technology (NTNU). The current thesis is inspired by a genuine interest and love for physical activity and nature, in combination with psychologically rooted thematics that has been reviewed throughout the courses of the master program. The author of the current thesis has been responsible for collecting and analyzing the data, and for development of research questions.

I would like to express great thankfulness to my supervisor, Hermundur Sigmundsson (NTNU), who has contributed with inspiration, continuous guidance and support throughout the process of this master's thesis. I would also like to thank my co-supervisor Håvard Lorås (NTNU), for valuable feedback on methodological issues. It has been a privilege to work under such knowledgeable persons.

Further, I'm grateful to all the participants who attended the experiment and made it possible for me to carry out this study. Also, I want to thank Berte Figenschou Amundsen and her colleagues at Norges Geologiske Undersøkelse (NGU) for assistance and for letting me dispose an office room for the execution of the experiment at Ladestien. I would also like to thank Thomas Simonsen and the rest of the friendly staff members at NTNU Dragvoll Sports Center, who allowed me to conduct the experiment in their gym.

Last, I would like to thank my family and friends for patience, love and support. Thank you, Emil, for always making me laugh and for greeting me with smiles. You have all taught me to appreciate the value of nature.

Ane Oline Roland
Trondheim, May 2017

"In every walk with Nature one receives far more than he seeks."

John Muir

Abstract

The aim of the current thesis was to investigate the effects of acute physical activity on sustained attention, indoors versus outdoors in natural environments. The current study is based on an integration of nature exposure-cognition field (Kaplan, 1989), and the acute physical activity-cognition field (Easterbrook, 1959; Yerkes & Dodson, 1908). In the current study, a between-subjects experiment was conducted. Participants (N=20) were randomly assigned to either an outdoors condition (n=10) or an indoors condition (n=10). A Deary-Liewald Choice Reaction Time (CRT) task, which constituted a measure of sustained attention, was conducted prior to (pretest), and immediately following (posttest) 30 minutes of moderate intensity physical activity. In addition, participants did conduct two standardized questionnaires that pictured participants' physical activity routines and connectedness to nature. The findings indicate that in both groups, acute physical activity in general, appeared to have a positive influence on sustained attention performance, regarding speed of processing. Of significant findings was an improvement on the posttest on accuracy of responding, within the outdoors group. However, the findings show that acute physical activity in natural environments doesn't provide any "added" effect on sustained attention, when comparing change between pretest and posttest of the CRT task between the groups.

Keywords: Acute physical activity, sustained attention, indoors, natural environments

Table of Contents

Introduction

The current study attempts to investigate the effects of acute physical activity on sustained attention, indoors versus outdoors in natural environments. In recent years, there has been growing interest in nature's potential influence on human health and well-being. But, this concern may be traced to older roots. The biophilia hypothesis suggested by Wilson (1984) states that humans have an inborn affinity for nature and other living organisms (Kahn, 1997). However, today's increasing urbanization is associated with that human-nature interactions are gradually declined. For instance, 54 per cent of the world's population live in urban areas. In addition, in 2050, it's expected that 66 per cent of the world's population is residing in urban areas (United Nations, 2014). Furthermore, seen from a global perspective, people are less physically active than before. Since 1980, worldwide obesity has more than doubled. In 2014, it was estimated that almost 40 % of adults aged 18 years and older were characterized as overweight (World Health Organization, 2016). Concerning the cognitive aspect of the current thesis, it's focused on sustained attention due to its necessity for other aspects of attention, as selective and divided attention, and for cognitive capacity in general. Furthermore, sustained attention is involved in many everyday situations, as efficiently communication between people, where detecting social cues is favorable (Sarter, Givens & Bruno, 2001). Moreover, sustained attention acts as a form of self-control (Bruya, 2010), which is shown to provide to both prominent level of academic success and happiness (Tangney, Baumeister & Boone, 2004).

Western society is in many ways characterized by individualism, efficiency and profit orientation. Thus, in line with this way of living, quick solutions to everyday challenges is considered as tempting to many people. For instance, we strive to achieve the *immediate* effects of single bouts of physical activity to get a healthy body and brain function. At the same time, some modern people need to make an escapism from the urban life into the nature for physical activity concerns or to gain spiritual energy (Gelter, 2000). However, for practical reasons, many people choose to exercise indoors. Some believe that physical activity indoors than outdoors promotes social contact and serves motivation to frequent physical activity (Hug, Hartig, Hansmann, Seeland & Hornung, 2009). In this context, it's relevant to ask whether physical activity does matter for sustained attention, and if so, does it matter if physical activity is done indoors or outdoors in natural environments.

In agreement with the investigation of the effects of acute physical activity on sustained attention, in two distinctive environmental settings, it has been appropriate to integrate two different research fields. One field is concerned with the cognitive benefits of interacting with natural environments (Kaplan, 1995; Kaplan & Kaplan, 1989). The other field concentrates on interactions between acute physical activity and cognition (Easterbrook, 1959; Yerkes & Dodson, 1908). This will be explained in detail in the theory section.

There is sufficient research supporting the idea that nature exposure on one hand, and acute physical activity, on the other hand, is associated with improved cognitive function. However, no or few studies have integrated the aspect of a comparison of indoors environments' and natural environments' influences regarding cognitive performance following acute physical activity. Still, such comparisons have been made within research focusing on physical activity-emotion interactions. For instance, a systematic review investigated physical activity in natural environments versus physical activity indoors and its effect on physical wellbeing and *emotional* variables, such as mental wellbeing. The researchers found that increased energy, greater feelings of revitalization and positive engagement was associated with physical activity in natural environments compared to indoors physical activity (Thompson Coon, Boddy, Stein, Whear, Barton & Depledge, 2011). Also, a systematic review by Bowler, Buyung-Ali, Knight and Pullin (2010) looked at potential "added benefits" to health of physical activity in natural environments compared to more synthetic environments. The results suggested positive effects on peoples' wellbeing due to physical activity in natural environments in comparison to more synthetic environments. Consequently, the author of the current thesis called for similar investigations within the physical activity-cognition paradigm and identified a need to examine the possible influence of natural environments on sustained attention following acute physical activity.

Defining Attention

Traditionally, from a neuroscience perspective, attention has been thought as a vague brain capacity. Still, attention represents separate sets of neural areas which is interacting with other parts of the brain (Posner & Petersen, 1990; Petersen & Posner, 2012). Attention is defined as a collection of cognitive processes that allow us to focus on selected information in the environment. Also, attention enables maintained processing of information (Cohen, 1993). Petersen and Posner (2012) suggest three basic concepts regarding the attention system. First, the alerting network is characterized by sustained attention mostly related to brain stem arousal systems. Second, the process of selecting a visual location or prioritizing sensory input, typified as the orienting network, is prominent in parietal cortex (Petersen & Posner, 2012). Third, executive networks, which mainly operates in midline and anterior cingulate cortex, captures awareness in a specific way and represent inhibition, inference control and cognitive flexibility (Diamond, 2013; Petersen & Posner, 2012).

Despite an attempt to restrict attention to a separate construct, it's important to recognize that attention in broad sense operates in several cognitive functions. For instance, executive functions are characterized by the ability to act flexibly, controlled and goal-directed adapted to the environment (Diamond, 2006). Both attentional control, working memory and inhibition represents basic functions within executive functioning (Ramstad, 2014). Although one might recognize attention and executive functions in relation to each other, the current thesis focuses on one aspect of attention; sustained attention.

Sustained attention. Sustained attention refers to a psychological construct which is characterized by the ability to focus attentional capacity on a task or an activity over prolonged periods of time (Bruya, 2010). Moreover, sustained attention describes a fundamental component of attention which involves that an individual, over an extended period, can detect infrequently and unpredictable stimuli. Human imaging studies demonstrate that sustained attention performance is associated with right-hemisphere mechanisms in frontal and parietal cortical areas of the brain (Sarter et al., 2001). However, in terms of localizing sustained attention, sustained attention is described as a function based on aligned circuits. Animal experimental evidence suggest that a central link in the mediation of sustained attention is the cortical cholinergic inputs (Sarter et al., 2001). Also, sustained attention creates relationships with other forms of attention and cognitive function in general, meaning that it exists overlaps in circuits mediating distinct forms of attention (Cabeza & Nyberg, 2000; Sarter et al., 2001).

***Measuring sustained attention*.** The reaction time paradigm is often a preferred approach in the study of physical activity-cognition interactions (Davranche, Audiffren & Denjean, 2006). Simple tasks that primarily require rapid decisions and automatized behavior are examples of sustained attention tasks. Simple or choice reaction time tasks, often described as «visual response time» tasks are mostly used (Sarter et al., 2001). In simple choice reaction time tasks, when a given stimulus is shown, the participant is instructed to press a relevant button on a computer keyboard as fast as possible without false responding. Similarly, in the choice versions, the participant responds by pressing the button that complement with the lighted stimulus. In this version, there are two or four stimuli displayed (McMorris, 2016; Sarter et al., 2001). Nor decision making, short- or long term memory is essential for reaction time tasks performance (Dietrich and Sparling, 2004; McMorris, 2016). They do however require the ability of stimulus identification, quick responding and the ability to focus attention over an extended period of time. In addition, when speaking of improved reaction times in sustained attention tasks, a distinction goes between speed versus accuracy of cognition (Posner, 1978). A meta-analytical investigation examined the relationship between speed and accuracy regarding differing intensities of acute physical activity and concluded that faster speed of processing, and not accuracy, was shown when experiencing increased arousal during moderate intensity physical activity (McMorris & Hale, 2012).

Attention Restoration Theory (ART) and Restorative Environments

It´s especially one theory that has had major influence on the research that revolves around restorative qualities of natural environments. Maas and Verheij (2007) argue that trees, forests, parks and even public gardens are examples of natural environments. Attention Restoration Theory (ART), first suggested by Kaplan and Kaplan in 1989, assumes that nature has qualities that make it possible for the brain to restore its attentional capacity. The ability to direct and sustain attention is effortful and requires amounts of cognitive control. When focus is directed towards a task, it’s appropriate to ignore irrelevant information for optimal performance. After extended use of effortful mental capacity, the experience of mental fatigue is a common phenomenon. Challenges regarding mood regulation and concentration may be present following sustained mental activities (Hartig, 2007; Kaplan, 1995). Once fatigued from everyday challenges, tasks and activities, a need for restoration is created. In a similar manner that sleep provides one approach to recovery, nature exposure serves to promote a shift in attention which in turn makes one function more optimally (Kaplan, 1995).

Kaplan (1995) emphasizes four characteristics that define what makes an environment restorative. It’s emphasized that the environment must have qualities that makes one feels (1) *being away*. Natural environments are often preferred places one wants to go for restorative opportunities. However, excursions to destinations far away (e.g., seaside or mountains) aren’t an option for everyone due to practical challenges. Being away can also means to engage in natural surroundings that is easily accessible, for instance in a local green city park. For an environment to generate (2) *fascination*, there needs to be cues in the environments that capture one’s attention in an effortless and undramatic fashion. Fascination is synonymous with attention that is driven by interests and is identified by objects and processes which people find absorbing. For example, wild animals, sunsets or waves might trigger fascination.

Another essential characteristic of a restorative environment is (3) *extent*. Wilderness areas are considered restorative because of fascinating elements that capture our attention. However, an environment has extent only if the sensations experienced make such a strong emotional impression that our cognitive capacity is fully engaged with it. In addition, there should be (4) *compatibility* in human-nature interactions. For instance, nature may offer intriguing stimuli, as steep mountains or waves. Any person who appreciates such features of nature, should in turn “give back” to nature by treating it respectfully and act carefully. In this way, a unity between man and nature is created (Kaplan, 1995).

Prominent research on nature exposure-cognition field. Considering the field of cognitive benefits of interacting with nature, the pioneering work by Ulrich (1984) is one of the first studies to exemplify that merely viewing a window of a natural environment can have restorative effects on people. The study examined whether patients recovering from surgery with a window view of natural settings or a neutral view of a “built” scene, had different experiences regarding the recovery phase. The results indicated that the patients having a room with a window view of nature experienced shorter postoperative hospital stays and received fewer negative evaluative explanations in their health journals. The work by Ulrich (1984) has laid the foundation for further research on the topic of restorative qualities of nature exposure.

ART is used as theoretical grounds in several studies (e.g., Berman, Jonides & Kaplan, 2008; Berman et al., 2012; Berto, 2005; Bratman, Hamilton & Daily, 2012; Chang, Hammitt, Chen, Macknik & Su, 2008; Hartig, Evans, Jamner, Davis & Gärling, 2003; Tennessen & Cimprich, 1995). For instance, Tennessen and Cimprich (1995) suggest that basically looking at nature can represent an attention-restoring experience. The researchers tested 72 undergraduate students’ capacity to direct attention using both subjective (e.g., the attentional function index) and objective (e.g., digit span forward and backward, and the necker cube pattern control test) measures. In the line with what Tennessen and Cimprich (1995) hypothesized, the results showed that the students who had natural views from their dormitory windows, showed better abilities of directing attention compared to those with less natural views.

Another study, by Berman, Jonides and Kaplan (2008), showed that directed-attention abilities can be improved by either viewing pictures of nature or by walking in nature. For instance, in one within-subjects experiment, the backwards digit-span task was used as a measure of directed attention performance on 38 participants. First, after performing the backward digit-span task, mental fatigue was induced. Then they were asked to take a 50-minutes’ walk in either a natural environment or downtown. When performing the attention task once again, performance on backwards digit-span task significantly improved when participants had walked in nature, as compared to when they walked in the urban area. Summarized, the results indicated that walking in nature has a restorative effect on human attention.

Physical Activity and Cognition

***Defining physical activity*.** Ortega, Ruiz, Castillo and Sjöström define physical activity as "any body movement produced by muscle action that increases energy expenditure" (2008, pp. 1-2). Physical exercise, on the other hand, is characterized by planned, repetitive and structured physical activity, often motivated by skill- or health-related goals (Caspersen, Powell & Christenson, 1985). In contrast, sedentary behavior is marked by minimal energy expenditure (Niet, Smith, Scherder, Oosterlaan, Hartman & Visscher, 2015).

Physical activity intensities often distinguish between aerobe and anaerobe. The terms heavy, moderate and low physical activity intensities are widely used in acute physical activity-cognition interactions research (McMorris, 2016). Moderate to relatively heavy intensity physical activity that a person can conduct over a prolonged time is what characterizes aerobe physical activity. Examples of aerobe physical activity are walking or running. Anaerobe physical activity represents heavy intensity physically work which last for a short time. It might for instance be lifting heavy weights or interval running (Henriksson & Sundberg, 2008). An individual's maximal oxygen uptake (VO_{2MAX}) appear to be a common indication of physical activity intensities. Low intensity physical activity is typified as being $\leq$30% VO_{2MAX} (Kamiljo, Hayashi, Sakai, Yahiro, Tunaka & Nishihira, 2009). Further, it has generally been claimed that moderate intensity physical activity is approximately 70% VO_{2MAX} (Wisløff, 2007). Finally, exercise intensities of $\geq$80% VO_{2MAX} is heavy intensity physical activity (McMorris, 2016).

Regarding duration of physical activity, a distinction goes between acute and chronic, whereas acute physical activity represents a single bout of aerobic training. A typical duration of acute physical activity lies between 10 and 40 minutes. Chronic exercise, on the other hand, means sessions with physical activity which is repeated for prolonged periods of time. For instance, numerous training sessions per week spanning between six and 30 weeks commonly represent chronic physical activity (Verburgh, Königs, Scherder & Oosterlaan, 2013).

Physical activity and health. Today it's accepted that physical activity is good for health. In 2014, the Norwegian Directorate of Health recommended adults and older people

150 minutes of moderate physical activity each week, alternatively 75 minutes of high intensity physical activity each week. A minimum of 60 minutes of moderate to heavy, varied physical activity each day was advised for children and young adults (St.meld. nr. 18 (2015-2016), 2016, p. 18). Research indicate that physical activity has a positive effect on various mental disorders, for instance depression, anxiety and schizophrenia (Herring, O´Connor & Dishman, 2010; Pedersen & Saltin, 2015). In addition, considerable evidence suggest that chronic physical activity has the potential of inducing neurobiological processes in the brain, advantageous for cognitive functioning (Barenberg, Berse & Dutke, 2011). Also, Kramer and Erickson's (2007) review suggests that if regular physical activity across life span is maintained, one is able of receiving enhanced cognitive vitality and considerable protection against the development of neurological disorders, such as Alzheimer's disease.

Underlying mechanisms of physical activity-cognition interactions. Several structural and functional changes in the brain, induced by physical activity, has been documented. These changes have been mostly found in the probably best studied region when it comes to physical activity-cognition interactions; the hippocampus. Hippocampus is the major structure for spatial learning and memory (Cotman, Berchtold & Christie, 2007). However, the effects of physical activity-cognition interactions might be seen at a systematic, molecular and cellular level. Regarding the systematic level, increased activity, brain volume and blood flow is shown, as a result of physical activity, in brain regions mediating attention, learning and memory. This is documented by electrophysiological and neuroimaging studies (Ratey & Loehr, 2011).

Within the molecular level by which physical activity affects cognition, neurotrophins (BDNF) and growth factors are highly included. For instance, BDNF is a molecule, most often found in hippocampus, which is crucial for synaptic plasticity, learning and memory (Cotman et al., 2007; Ratey & Loehr, 2011). Ferris, Williams and Shen (2007) found in young adults that acute physical activity led to increased levels of BDNF. On the other hand, the cellular level consists of synaptic plasticity, neurogenesis and angiogenesis (Ratey & Loehr, 2011). One example of the physical activity-induced changes within the cellular level is the increase of number of new neurons in the adult hippocampus (Trejo, Carro, Torres-Alemán, 2001).

Theories on Acute Physical Activity-Cognition Interactions

The inverted-U theory. The interactions between acute physical activity and cognition are complex. However, there are theoretical underpinnings that emphasize that moderate intensity physical activity lasting for more than 20 minutes is an optimal zone of physical activity intensity for the sake of improving cognitive performance (Brisswalter, Collardeau & René, 2002). This is in line with Easterbrook's (1959) cue utilization theory, which has played a major role in this field. Easterbrook's (1959) theory includes adaptions of Yerkes and Dodson's (1908) inverted-U theory, which claims that physical activity is interpreted as being a stressor. Pribram and McGuinness (1975) saw stressors as being physiological or mental arousal that make people experience increased alertness and attention. Yet, the inverted-U theory emphasizes that cognitive performance will be poor when arousal is low. In contrast, when the arousal level increases to moderate, optimal cognitive performance can be achieved. Even more importantly is that cognitive performance will decrease in the same manner as when arousal is low, if arousal continues to raise.

Easterbrook (1959) goes on in the explanation of how arousal is affecting cognitive performance, and argues that a wide focus of attention is seen when the levels of arousal is either too low or too high. In other words, the focus will be directed towards both relevant and irrelevant information in the environment. This information represents surrounding cues that an organism in each situation observes, maintains attention towards or responds to. Furthermore, attention is narrowed and task relevant cues are processed effectively when arousal rises from low to high, achieving a moderate state of arousal. In this case, attention reaches an optimal level, and considering the theory of Yerkes and Dodson (1908), this agrees with what constitutes the top of the inverted-U curve.

To look at the strengths of the inverted-U theory in predicting performance effects, several meta-analyses (e.g., Chang, Labban, Gapin & Etnier, 2012) fail to support an inverted-U effect. However, a meta-analysis that appears to show an inverted-U effect is the one of McMorris and Hale (2012). The researchers concluded that faster speed of processing resulted of increased arousal during moderate intensity physical activity, demonstrating a medium effect size (g=0.30). Non-significant effect sized very close to zero was reported for low and heavy intensity physical activity.

***The transient hypofrontality hypothesis*.** Researchers have for decades tried to explain the physical activity-cognition interactions by offering a neurochemical explanation of the phenomenon (Dietrich, 2006). For instance, McMorris (2009) developed a neuroendocrinological model for an interaction between physical activity and cognition. The model proposes an interaction between the sympathoadrenal system (SAS), which is a part of the autonomic nervous system (ANS) and HPA. It further suggests that during physical activity, this interaction might lead to synthesis and secretion of various catecholamines (e.g., dopamine, noradrenalin and adrenalin), 5-HT, which is better known as serotonin, and cortisol.

In contrast to the neuroendocrinological model contributed by McMorris (2009), the transient hypofrontality hypothesis provides a coherent account of the influences of physical activity on cognition and emotion taking the perspective of limited brain capacity processing. More specifically, the transient hypofrontality hypothesis refers to a cognitive and neuroscientific theory that focuses on the effects acute physical activity has on cognition *during* physical activity. Many neural structures across the entire brain are active during physical activity. Physical activity activates sensory and autonomic regions of the brain including motor regions responsible for generating the motor patterns associated with the physical activity (Dietrich, 2006). Since cerebral blood flow (CBF) and local cerebral glucose utilization (LCGU) both are important indicators of functional activity of neurons, Vissing et al., (1996) aimed to investigate this neural activity in specific brain regions in non-human animals while exercising. Among other things, during exercise they found increases in LCGU in gray matter structures associated with autonomic, sensory and motor function.

Despite that physical activity requires massive neural activation of the brain, one must not be led away from the notion that processing in the brain is competitive. This means that the brain has a limited information processing capacity (Dietrich & Sparling, 2004; Dietrich, 2006). Considering the general proposal of the brain's limited information processing capacity, the transient hypofrontality hypothesis emphasizes that activation of structures involved in physical activity must come at the expense of other structures involved in higher-cognitive abilities in the prefrontal cortex. However, in its original form, a transient decrease in prefrontal regions is explained due to that this region is not directly essential to the maintenance of the physical activity. But another way, the brain does "priorities" and then choose to downregulate regions that are not crucially involved in the current behavior (Dietrich, 2003). In turn, the transient hypofrontality hypothesis predicts decreased performance on cognitive tasks that relies on structures in prefrontal cortex during physical activity. On the other hand, performance on tasks that doesn't depends heavily on prefrontal structures will not be affected during physical activity (Dietrich, 2006).

The results of two experiments designed by Dietrich and Sparling (2004) act as evidence in supporting the transient hypofrontality hypothesis. The results of their studies indicated a decrease in performance on tests what was prefrontal-dependent during physical activity. In contrast, performance on tests that required little prefrontal activity, was unaffected.

Prominent research on the acute physical activity-cognition field. Several researchers (e.g., Audiffren, Tomporowski & Zagrodnik, 2008; Brisswalter et al., 2002; Davranche & Audiffren, 2004; McMorris, 2016; Pesce & Audiffren, 2011; Tomporowski, 2003; Tomporowski & Ellis, 1986) have over the past 50 years investigated the relationship between cognitive function and acute physical activity. A review of Etnier, Salazar, Landers, Petruzzello, Han and Nowell (1997) seem to be one of the earliest and most influencing review paper that has been published within acute physical activity-cognition research. However, the researchers concluded that acute physical activity did not have a meaningful positive impact on cognition. In contrast, chronic physical activity was regarded as a more useful intervention for enhancing cognitive abilities, they claimed. In other words, they emphasized the importance of future comprehensive reviews since the results proved to be inconsistent.

On the other hand, of more recent meta-analyses, cognitive benefits of acute physical activity were shown. Lambourne and Tomporowski´s work (2010) was concerned with acute physical activity in which cognition in young adults was measured during and immediately following physical activity. Concerning cognitive task performance following physical activity, the results showed improvement by a mean effect of 0.20, indicating a small to medium improvement. In addition to enhancement in memory storage and retrieval, the researchers could report acceleration in mental processes when participants achieved optimal level of arousal. In contrast, during the physical activity, impairments on the cognitive task performance was observed. However, the impairments lasted only during the first 20 minutes of the physical activity. Nevertheless, on tasks dependent on automatized behaviors as rapid decisions, enhancement in performance was seen. Also, it’s worth mentioning that different types of physical activity (e.g., treadmill running versus cycling) had different effect on cognitive performance. Treadmill running was associated with a small improvement in cognitive performance following physical activity, whereas impaired cognitive performance was observed during physical activity. On the other hand, enhanced cognitive performance was observed both during and following cycling.

Despite the complex relationship between physical activity and cognition, the tendency in the review mentioned above points towards a positive association between cognitive task performance and acute physical activity. In addition, Tomporowski (2003) emphasizing the ability of enhanced vigilance and sustained attention following acute physical activity. However, whether improved cognition is due to the intensity, duration or at what time the cognitive capacity is being measured, is not fully clear. Thus, many of the studies that exist in this field have focused on measuring cognitive capacity during the physical activity, in contrast to immediately following physical activity (McMorris, 2016). For instance, Guizani, Bouzaouach, Tenenbaum and Kheder (2006) found that physically active people showed shorter CRTs at 40 %, 60 % and 80 % of VO_{2MAX} during physical activity as compared to sedentary people during exercise and while resting. Also, nonsignificant effects for SRTs was shown for both groups.

The Norwegian Culture of *Friluftsliv*

Friluftsliv ("free-air-life") is normally understood as spending time in nature to slow down, regain energy and attempting to experience a sense of freedom. *Friluftsliv* represents a philosophical lifestyle which is deeply rooted in Norway, and in the Scandinavian cultures respectively. An important part of the peoples' lives in these cultures is to be able to live close to wonderful landscapes and to engage in activities in nature in their spare time. This might work as an escapism from urban life and has the potential to restore physical and psychic strength.

Gelter (2000) argues of two conceptualizations of *friluftsliv* and describes *"genuine friluftsliv"* in terms of strong emotional and spiritual connectedness to nature. The pure presence and immersion in nature provides a closeness to the landscape and the more-than-human world which has an aesthetic, biological and social character. In accordance with Fridtjof Nansen (1861-1930), a famous polar explorer and scientist, spending time in nature is the true way back home (Gelter, 2010). In contrast to *"genuine friluftsliv"*, "*post-modern" friluftsliv* is more prominent among urban people today. The latter definition is associated with plain outdoor activities (e.g., canoeing, hunting and fishing). Urbanization, commercialization and sportification has contributed to changes in the way human relate to nature, representing a "quick fix" in natural settings, away from the speedy every-day life. However, passive nature experiences typical for *"genuine friluftsliv"* and the more sportified activities in *"post-modern" friluftsliv* might interact with each other. This means that canoeing might be preferable, whereas the goal is not the activity itself, instead, the desire is the experience of presence and connectedness to nature (Gelter, 2000; Gelter, 2010).

As mentioned, *friluftsliv* offers activities in nature where physical activity is a critical element. In fact, *friluftsliv* is the most usual form of physical activity in Norway. 61 percent of the Norwegian population reported that physical activity in nature serves the preferred activity that they want to do more of in the future. Also, *friluftsliv* is central to the government´s work on public health, notably because many of us are not sufficiently physically active (St.meld.

nr.18 (2015-2016), 2016, p. 7). Statistics from the Norwegian Directorate of Health in 2011 could warn that people in the age group 65-85 years are less sedentary than Norwegian 15-year-olds (St.meld. nr. 18 (2015-2016), 2016, p. 15).

Current Study

The goal of the current study was to examine the effects of acute physical activity on sustained attention, indoors versus outdoors in natural environments. The nature exposure-cognition field and the acute physical activity-cognition field have laid the foundation for the development of shaping the research questions of the current study. Within the nature exposure-cognition field, the current experiment was designed as a further development of the studies based on Attention Restoration Theory (ART). Some examples are studies that did a comparison of natural views versus less natural views (Tennessen & Cimprich, 1995), and walking in nature versus downtown in urban areas (Berman et al., 2008), and its effect on human attention. These studies constituted an inspiration to investigate the potential "added" cognitive benefits of natural environments by comparing indoors environments versus genuine natural environments. Furthermore, within the experimental setting, genuine natural environments were regarded valid and ideal in the conduction of the current experiment, compared to artificial nature. Indeed, research supports the idea that genuine natural environments, to a greater extent than more artificial natural environments, provide restorative qualities (Kjellgren & Buhrkall, 2010).

Moreover, speaking of the cognitive tests usually used within research based on ART, many studies (e.g., Berman et al., 2008; Berman et al., 2012; Tennessen & Cimprich, 1995), used among other tasks, the backwards digit span task, as a measure of directed-attention capacities. However, it's argued that the backwards digit span task represents a measure of working memory (Diamond, 2013). Thus, the backwards digit span task was not applicable in the current study. Yet, it was preferred to clarify directed-attention capacities more precisely, so it was focused more specifically on one attentional construct; sustained attention. Consequently, despite only one measure used in the current study, a choice reaction time (CRT) task was considered as a reliable and precise measure of sustained attention (Sarter et al., 2001). Two variables of the CRT task indicate great performance. As McMorris and Hale (2012), the current study deals with shorter reaction times, as an indicator of improved posttest CRT task performance. In addition, accuracy of correct responding is associated with good cognitive performance.

Regarding the contributions from the physical activity-cognition interactions field, in shaping the research questions of the current study, the inverted-U theory emphasized by Yerkes and Dodson (1908) and Easterbrook (1959) has made profound influence. For instance, the Inverted-U theory states that moderate arousal levels are associated with optimal cognitive performance. This knowledge led to determine that participants should engage in moderate intensity physical activity during the current experiment. Thus, it was hypothesized that this intensity would be most beneficial in terms of CRT task performance. This theoretical basis is consistent with research findings suggesting faster speed of processing of moderate intensity physical activity compared to low or heavy intensity (McMorris & Hale, 2012). Thus, the physical activity of running was considered easier to carry out practically, compared to other physical activities, as cycling.

In the current study, a between-subjects experiment was conducted. 20 students (aged 20-28) were randomly selected to either a control group (n=10) or an experimental group (n=10). In the experimental condition, participants were instructed to run 30 minutes of moderate intensity in natural environments. A Deary-Liewald CRT task was performed indoors prior to and immediately following the running session. The same procedure was applied to the control group, except that the run took place indoors on a treadmill. Despite that the physical activity literature shows mixed findings regarding the acute physical activity-cognition interactions, one gets certain expectations about the outcome of the current study. For instance, based on the studies of (Guizani et al., 2006; Lambourne & Tomporowski, 2010; McMorris & Hale, 2012; Tomporowski, 2003), shorter reaction times and more accurate responding following physical activity is expected. In addition, based on findings of several studies (e.g., Berman et al., 2008; Ulrich, 1984; Tennessen & Cimprich, 1995) within nature exposure-cognition field, it was expected an "added" cognitive benefit for participants engaging in physical activity outdoors in natural environments compared to physical activity indoors. The research questions are:

- I: Does acute moderate intensity physical activity itself, has a significant effect on CRT task performance within the outdoors group and the indoors group?
- II: Is the change between pretests and posttests of the CRT task in the outdoors group significantly different from the change between pretests and posttests of the CRT task in the indoors group?

Method

Research Design

The aim of the current study was to explore the effects of acute physical activity on sustained attention, indoors versus outdoors in natural environments. The current study applied a between-subjects design, in a repeated measures experiment. The experiment was carried out over two different periods with two different experimental conditions; (1) running indoors on a treadmill, and (2) running outdoors in natural environments. After participants completed the International Physical Activity Questionnaire (IPAQ) and the Connectedness to Nature Scale (CNS), they performed the pretest of the Deary-Liewald CRT task (Deary, Liewald & Nissan, 2011). Further, participants either went for 30 minutes of moderate intensity physical activity indoors on a treadmill, or 30 minutes of moderate intensity physical activity outdoors in natural environments. Finally, the posttest of the Deary-Liewald CRT task was performed. Moderate intensity physical activity either indoors or outdoors in natural environments, represented the independent variables. The dependent variable was the CRT task performance. The study was accepted by the Norwegian Social Data Service (NSD) (see Appendix A). See table 1. for illustration of the design.

Table 1.

Experimental design. The table describes how and in which order the various parts of the experiments were conducted.

	Step 1	Step 2	Step 3	Step 4
Outdoors group	Questionnaires	Pretest CRT task	Moderate intensity PA – natural environments – 30 min.	Posttest CRT task
Indoors group	Questionnaires	Pretest CRT task	Moderate intensity PA – indoors – 30 min.	Posttest CRT task

Note. PA = Physical activity. CRT task = Choice reaction time task.

Participants

Healthy, Norwegian-speaking students (N= 20; 16 women and four men) ranging in age from 20 to 28 years old (M = 23.3 years, SD = 2.4), from the Norwegian University of

Science and Technology (NTNU), voluntarily participated in the experiment. Participants were recruited through enquiry on message boards primarily at NTNU Dragvoll Campus in Trondheim. People who were interested in participation could voluntarily send an email to the project manager to confirm his or her interest. 10 participants were randomly assigned to each of the two conditions. There was no requirement for participants' assumptions regarding physical fitness, daily physical activity routines or personal interest in nature. The participants were offered 100 NOK each for participation in the experiment. Written informed consent was obtained from all participants and they were told that they could withdraw at any time (see Appendix B). Participants were sent a copy to their mailbox of the written informed consent. Note that the consent paper showed in appendix is somewhat misleading, among else that two, and not three, experimental conditions were included in the current study.

Experimental Conditions

As mentioned, the experiment was carried out in two different environmental settings. Participants who were randomly selected to the indoors condition, conducted the experiment at Dragvoll Sports Center in Trondheim. The experiment was divided into two parts; an attention task part and an activity part. The attention task part took place inside the Dragvoll Sports Center on a single, midsize room without disturbing sounds or elements (see Appendix C). Here, participants answered the questionnaires and conducted the pretest and the posttest of the Deary-Liewald CRT task. The activity part consisted of a treadmill (Life Fitness Integrity) placed among other treadmills and close to other people that were exercising (see Figure 1). Music was played on the gym's speakers. On the other hand, participants who attended the outdoors condition, conducted the experiment on a popular seaside path in Trondheim, called Ladestien (see Figure 2). Correspondingly, the experiment consisted of two parts; an attention task part and an activity part. Regarding the attention task part, participants answered questionnaires and conducted the pretest and posttest of the Deary-Liewald CRT task indoors in an office room in a building near Ladestien. The room used was like the one at the Dragvoll Sports Center (see Appendix D). The building used for carrying out the attention task part of the experiment, was a practical location since the distance to Ladestien, where the activity part took place, was just a few minutes of walking away. Speaking of the activity part, Ladestien is one of Trondheim's most popular recreation areas (Trondheim kommune, 2017). People either bicycle, run or walk along the almost 8-km long seaside path. However, some prefer to visit the cafés, swim in the ocean or rent a kayak. This area thus consists of a mixture of human intervention and natural beauty of open fields and green forests (see Figure 3). The experiment at Dragvoll Sports Center was carried out on a few days late in November 2016. In contrast, the experiment at Ladestien was conducted early in November 2016. Two days following each other was used for experiments at Ladestien, whereas the one day was a bit rainier, windier and colder than the other.

Figure 1. Image of the treadmill and the surrounding environment at Dragvoll Sports Center.

Figure 2. Photo from Ladestien with natural surroundings, taken one of the days the experiment was conducted.

Figure 3. Map view of Ladestien, which represents the path from “Korsvika” to “Rotvoll”.

Measures

Questionnaires. Two questionnaires given in paper format were used in the data collection. First, the short version of the International Physical Activity Questionnaire (IPAQ) was conducted by participants to measure their daily physical activity routines (see Appendix E). Research has demonstrated that IPAQ instruments provide reliable and valid physical activity data (Craig et al., 2003). The questionnaire consists of four main questions with associated sub-questions that aim to identify what kind of physical activity and the amount of time spent on any activity the last seven days. Likewise, the questionnaire accounts for the intensity of the physical activity. To calculate the data, thematically related questions were multiplied in SPSS. For instance, question 1a) and 1b) was multiplied to capture each participant's total amount of physical activity the last seven days, within different intensities. The amount was measured in minutes spent on physical activity the last seven days.

The other questionnaire was the Connectedness to Nature Scale (CNS) (see Appendix F). In research that deals with human-nature interactions, the CNS constitutes a fruitful empirical tool (Mayer & Frantz, 2004). The CNS contains 14 statements regarding an individual's emotional experience of feeling a relatedness with nature. Participants answered each statement by typing a number from 1 to 5 in front of each statement, whereas 1 represented "strongly disagree" and 5 represented "strongly agree". To find an average score for each participant, in SPSS, the sum of all responses was added together and divided by the number of total statements. Thus, a number from 1 to 5 represented participants' degree of connected to nature.

Heart rate measure. To ensure an experiment as standardized as possible and to check for potential confounding variables, all participants were asked to keep the physical exertion at moderate intensity level. Heart rate frequency during physical activity was recorded with a Polar M400 GPS running watch with associated Polar heart rate monitor belt. The heart rate monitor belt contains electrodes that captures the participant's heart rate. This information is sent to the running watch so that the participant who wears the running watch can notice their own heart rate frequency during the physical exertion. In the current experiment, the recorded data was not analyzed in any software, but instead deleted immediately following the experiment. This was because the information gained was just meant as guidance according to intensity.

Choice reaction time (CRT) measure. Choice reaction time (CRT) measures were recorded using the Deary-Liewald CRT task. This is an easy manageable, computer-based reaction time task which yields valid and reliable measures (Deary, Liewald & Nissan, 2011).

The task was run on a screen placed on a table with a refresh rate of 60 Hz. Each participant was seated comfortably on a chair with the screen about 50 cm from their face. A blue background was shown in the middle of the screen, where four white boxes were lying horizontally across the blue background (see Figure 4). The task proceeded in that a stimulus (the letter X) rapidly appeared in one of the four white boxes. The participant was instructed to press a button on the laptop keyboard, using the fore- and the middle finger on each hand, that corresponded to the appearing X. The X continued to randomly appear in one of the four boxes, with different time span between each trial, and reappeared when pressing a button. The performance of the task was to take place as quickly as possible and without errors, meaning an attempt to prevent pressing a button that didn't correspond to the X. The buttons that was meant to be pressed when the X appeared in one of the four boxes, represented four different keys on a regular laptop keyboard. More specifically, the "z" key should be pressed when the X appeared in the box on the far left. Further, the "x" key corresponded to the box one from the left. Similarly, when the X showed up in the box one from the right, participants should press the "comma" key. Finally, the "full stop" key corresponded with the X showed up in the box far right. It was a desire that the CRT task would last slightly longer than original. It was important to ensure that participants would focus attention on a task over a prolonged period, as this characterizes sustained attention (Bruya, 2010). When completely adjusted, the CRT task lasted for approximately 10 minutes. More specifically, the number of experiment trials was adjusted to 200, and response range was set to 200-5000 milliseconds. In addition, the interstimulus interval (ISI) was fixed to 1000-4000 milliseconds. These adjustments of the CRT task set up was done in accordance with how the 14-min Continuous Performance Test (CPT) is administrated. The CPT represents a leading measure for assessing different attentional aspects, especially within ADHD studies. Also, the CPT measures cognitive aspects that are important for sustained attention (e.g., vigilance and signal detection). This made the CPT applicable as guidance according to the CRT task set up (Conners, Epstein, Angold & Klaric, 2003). Of relevant variables that was recorded by the computer program was whether the response was correct or wrong (accuracy), and the mean reaction time of the correct responses (speed).

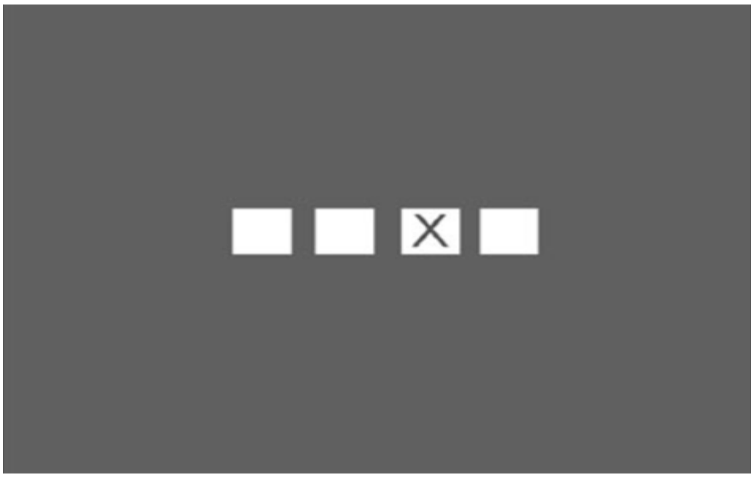

Figure 4. Illustration of the image that appears when performing the Deary-Liewald CRT task.

Procedure

Participants did the experiment alone without other participants present. Participants were told that the study investigated the effects on acute physical activity on sustained attention, indoors versus outdoors in natural environments. Afterwards participants received sufficient information about the study, they gave their written informed consent. Further, the International Physical Activity Questionnaire (IPAQ) and the Connectedness to Nature Scale (CNS) was completed using pen and paper. Then the pretest of the Deary-Liewald CRT task was performed on a regular laptop (Dell Latitude E4300). Participants were seated approximately 50 cm from the screen. This session took place indoors in a single room without disturbing sounds or elements. The participants were leaved alone while they performed the CRT task. At last, the participants were given a heart rate monitor belt with associated running watch that they should wear during the physical activity part of the experiment. They were told that they should try to stay within a certain heart rate zone, representing moderate intensity physical activity. As mentioned in the introduction, 70% VO_{2MAX} fall within moderate intensity physical activity (Wisløff, 2007). However, to find out what represented 70% VO_{2MAX} for each participant, individual age-predicted maximal heart rate was calculated. This was calculated by the formula 211-0.64*age. For instance, age-predicted maximal heart rate for a 24-year-old participant was 211-0.64*24 = 195.64. Furthermore, to calculate 70% of age-predicted heart rate, the formula 70* VO_{2MAX} / 100 was used. In case of a heart rate of 196, 70% VO_{2MAX} was calculated by 70*196 / 100 = 137 (Nes, Janszky, Wisløff, Støylen & Karlsen, 2013).

The next step of the experiment was the activity part, which either took place indoors or outdoors. The outdoors group (n=10), were asked to run for 30 minutes at Ladestien. With help from the heart rate monitor, participants returned after 15 minutes, so that they got to complete a 30 minutes' run. When completed, they returned to the place where the questionnaires and pretest CRT task was conducted, in this case at NGU. The posttest CRT task was conducted maximum ten minutes following the physical exertion due to control for arousal levels and possible other physiological confounds (Magnie et al., 2000).

Considering the activity part for the indoors group (n=10), participants were instructed to run for 30 minutes on a treadmill at the gym at the Dragvoll Sports Center. The treadmill used was placed close to other treadmills and among other people who were exercising. Similar with group I, the same requirements applied for group II regarding that the posttest CRT task should be conducted maximum 10 minutes following physical exertion. However, in this condition, questionnaires and pre- and posttest CRT task was conducted in a room inside the Dragvoll Sports Center. Following the experiment was completed, all participants (N=20) were handed over their gift of 100 NOK.

Statistical Analysis

T-tests were conducted to test the two research questions of the study. An underlying assumption in parametric testing is that the data has a normal distribution (Field, 2013). To test if the data met this assumption, the Shapiro-Wilk's test was conducted. This specific numerical method was chosen because the Shapiro-Wilk's test is suitable for small sample sizes (<50) (Leard Statistics, 2017). In terms of the Shapiro-Wilk's test, it´s assumed that the data were approximately normally distributed. Thus, the underlying assumption of normal data is met, so parametric statistics was used mostly. More specific, a Shapiro-Wilk's test (p>.05) showed that data was normally distributed for pretest correct responses; p = .266, for posttest correct responses; p = .192, for pretest mean RT correct responses; p = .161, for posttest mean RT correct responses; p = .680, and for CNS; p = .384. However, the heavy intensity physical activity $(PA)_{IPAQ}$; p = .007, the moderate intensity PA_{IPAQ}; p = .000, the low intensity PA_{IPAQ}; p = .006, and finally the physical $inactivity_{IPAQ}$; p = .009 was not normally distributed. On the few variables that were shown to not be normally distributed, nonparametric statistics was conducted. An alpha level of .05 was adopted throughout in the study.

In terms of group sample characteristics, an independent-samples t-test for data that met the assumption of normal distribution was conducted to analyze differences between the groups regarding scores on the questionnaires and on the pre- and posttest CRT task. An independent-samples t-test was conducted with CNS and scores on pre- and posttest CRT task as test variable. The grouping variable was the experimental condition (physical activity indoors or outdoors). Regarding data that met the assumption of normal distribution, a two independent Mann-Whitney U test was conducted with IPAQ as test variable. The experimental condition was the grouping variable.

To examine research question I, a paired-samples t-test was conducted to compare the change between pre- and posttest of the CRT task within each group. In the outdoors group, the test variable was the change between pre- and posttests of correct responses and the change between pre- and posttests of mean RT correct responses. The same test variable that was used in the outdoors group, was used in the indoors group. Furthermore, to examine research question II, an independent-samples t-test was conducted to test whether the change between pretests and posttests in the outdoor group was significantly different from the change between pretests and posttests in the indoor group. The test variable was the change between pre- and posttests of correct responses and the change between pre- and posttests of mean RT correct responses, whereas the experimental condition represented the grouping variable.

Results

Descriptive Statistics

Participants (N=20) were four men and 16 women aged from 20 to 28. The average age of participants was 23.3 years (SD = 2.4). The mean age for the outdoors group was 23.6 (SD = 2.4), whereas the mean age for the indoors group was 23 years (SD = 2.4).

Group Sample Characteristics

An independent-samples t-test for normally distributed data and a Mann-Whitney U test for skewed data was conducted to analyze the differences between the outdoors group and the indoors group regarding their scores on levels on the Connectedness to Nature Scale (CNS), physical activity routines measured by the short version of the International Physical Activity Questionnaire (IPAQ), and scores on pre- and posttest CRT task. The independent-samples t-test and the Mann-Whitney U test revelated that no significant differences existed between the two groups when it comes to scores on the CNS, scores on the short version of the IPAQ, and scores on pre- and posttest CRT task.

CNS. Regarding scores on the CNS, an independent-samples t-test showed that there was no significant difference between the two groups; t(18)=.274, p = .787. Mean values and standard deviations are shown in table 2.

IPAQ. A Mann-Whitney U test showed that there was no significant difference between the two groups in the scores on heavy intensity physical activity on the IPAQ; U = 49.5, p = .970. There was no significant difference between the two groups in the scores on moderate intensity physical activity on the IPAQ; U = 44.5, p = .675. In addition, no significant difference was found between the two groups in the scores on low intensity physical activity on the IPAQ; U = 35.5, p = .270. Finally, there was no significant difference between the two groups in the scores on sedentary behavior on the IPAQ; U = 45.0, p = .701. Mean values and standard deviations are shown in table 2.

Scores on pre- and posttest CRT task. An independent-samples t-test showed that there was no significant difference between the two groups on pretest correct responses; t(18)=-.217, p = .831, and posttest correct responses; t(18)=.792, p = .438. There was no significant difference between the two groups on pretest mean RT correct responses; t(18)=.141, p = .889, and posttest mean RT correct responses; t(18)=.792, p = 438. Mean values and standard deviations are shown in table 3.

Table 2.

Mean values (M) and standard deviations (SD) of in outdoors group and the indoors group on the International Physical Activity Questionnaire (IPAQ), representing minutes spent on physical activity the last seven days. The table also shows M and SD of both groups on the Connectedness *to Nature Scale (CNS).*

	Outdoors group (n=10)	Indoors group (n=10)
Variable		
Heavy Intensity PA_{IPAQ}	277.50 (294.22)	204.00 (164.41)
Moderate Intensity PA_{IPAQ}	195.00 (249.60)	125.00 (125.90)
Low Intensity PA_{IPAQ}	148.50 (124.23)	87.50 (68.53)
Sedentary $behavior_{IPAQ}$	474.00 (194.83)	516.00 (121.49)
CNS	3.16 (.44)	3.11 (.37)

Note. PA = Physical activity. Mean values on CNS vary from 1 to 5, whereas 1 represents weak sense of connectedness to nature, and 5 represents powerful sense of connectedness to nature.

Research Question I: Does acute moderate intensity physical activity itself, has a significant effect on CRT task performance within the outdoors group and the indoors group?

Within-group data. A paired-samples t-test was conducted to compare the change between pre- and posttests within the groups. In the outdoors group, there was a significant difference between pretest correct responses and posttest correct responses; t(9)=-2.36, p = .042. There was no significant difference between pretest mean RT correct responses and posttest mean RT correct responses; t(9)=.548, p = .597.

Regarding the indoors group, there was no significant difference between pretest correct responses and posttest correct responses; t(9)=-.28, p = .788. No significant difference was found between pretest mean RT correct responses and posttest mean RT correct responses; t(9)=.98, p = .354. Mean values and standard deviations are shown in table 3. The table also shows shorter mean RT on correct responses following acute physical activity in both the outdoors group and the indoors group.

Research Question II: Is the change between pretests and posttests of the CRT task in the outdoors group significantly different from the change between pretests and posttests of the CRT task in the indoors group?

Between-group data. An independent-samples t-test was conducted to compare the change between the groups. More specifically, the independent-samples t-test analyzed whether the change between pretests and posttests in the outdoors group was significantly different from the pretests and posttests the indoors group. There was no significant difference between change in the outdoors and indoors group on the variable correct responses; t(9)=-1.470, p = .159. On variable mean RT correct responses, no significant difference in change was found between the two groups; t(9)=-.359, p = .724.

Table 3.

Data from Choice Reaction Time (CRT) task. Mean values (M) and standard deviations (SD) of correct responses (accuracy), representing the number of correct trials ranging from 1 to 200. The table also shown M and SD of mean RT on correct responses (speed of processing) specified in milliseconds.

	Outdoors group (n=10)			Indoors group (n=10)		
Variable	Pretest	Posttest	Δ	Pretest	Posttest	Δ
Correct responses	187.60 (6.67)	191.00 (6.34)	-3.40	188.30 (7.72)	188.70 (6.63)	-0.40
Mean RT correct responses	435.04 (58.64)	431.96 (57.59)	3.09	432.08 (31.29)	425.96 (31.57)	6.11

Note. RT = Reaction Time. Δ = Change.

Discussion

The aim of the present study was to explore the effects of acute physical activity on sustained attention, indoors versus outdoors in natural environments. In the current experiment, two independent groups were exposed to two different environmental conditions. The groups answered questionnaires and conducted the pretest CRT task, next they did the activity part outdoors in natural environments or indoors on a treadmill. Finally, they completed the posttest CRT task. The current study questioned; (1) Does acute moderate intensity physical activity itself, has a significant effect on CRT task performance within the outdoors group and the indoors group? and (2) Is the change between pretests and posttests of the CRT task in the outdoors group significantly different from the change between pretests and posttests of the CRT task in the indoors group?

Overall, the findings indicate that acute physical activity in general seemed to explain a slightly improvement of speed of processing of the CRT task within the outdoors group and the indoors group. However, the only significant finding regarding acute physical activity's effect on sustained attention, was an improvement of accurate responding of the CRT task within the outdoors group. Thus, characteristics of the natural environments might explain why the outdoors group showed significant improvement on accuracy of the CRT task. Nevertheless, the current study doesn't find evidence that points towards that acute physical activity outdoors in natural environments, compared to indoors environments, is more beneficial for sustained attention performance. More research is needed to investigate this topic further.

Group Sample Characteristics

Regarding group samples characteristics, the results specify that no significant differences existed between the indoors group and the outdoors group regarding several characteristics. These characteristics were scores on the Connectedness to Nature Scale (CNS), the International Physical Activity Questionnaire (IPAQ), and pre- and posttest CRT task performance. The results suggest that the two groups were quite similar according to their connectedness to nature, physical activity routines and their response patterns relative to the CRT task. However, from Table 2. in the results section, it appears from the mean IPAQ scores, that participants in the outdoors group, spent considerably more minutes on heavy, moderate and low intensity physical activity compared to the indoors group. On the other hand, it appears that the indoors group spent more minutes on average on sedentary behavior compared to the outdoors group. In addition, the indoors group had a slightly lower score on the CNS, indicating a somewhat weaker sense of connectedness to nature. Though, despite that these differences were not statistically significant, it’s still a relevant finding because it might help to explain the research question I. See below.

Research Question I: Does acute moderate intensity physical activity itself, has a significant effect on CRT task performance within the outdoors group and the indoors group?

The results from the paired-samples t-test suggest that, acute moderate intensity physical activity did have significant effect on CRT task performance within the outdoors group, but not in the indoors group. More specifically, the outdoors group showed improved posttest CRT task performance in terms of more accurate responding following acute physical activity. To explain why the outdoors group showed more accurate responding following physical activity, it’s conceivable that this was due to their reported joy of being in nature, measured by the CNS. This in turn could have had a mediating effect on cognitive performance. In this respect, improved cognitive performance may not follow as a direct effect of exposure to natural environments. Rather, reduced autonomic arousal and positive emotions experienced in nature may have contributed to improved cognitive performance

(Ulrich, 1993). Furthermore, it’s possible that the natural environment applied in the outdoors condition was characterized by qualities that enabled restoration of the brain’s attentional capacity (Kaplan & Kaplan, 1989; Kaplan, 1995). More specifically, it’s likely that the result can be explained due to that the natural environment offered exciting stimuli that attached attention in a manner that is related to fascination. This in turn might have enabled rest of sustained attention. Still, the present significant result contrasts with the meta-analytical investigation of McMorris and Hale (2012), which emphasize that shorter reaction times, and not accuracy, is mostly shown during moderate intensity physical activity. However, McMorris and Hale (2012) were concerned with cognitive effects during physical activity, as in contrast to the current study, which focused on sustained attention performance following physical activity.

In terms of mean RT on correct responses of the posttest CRT task, no significant difference was found for either the indoors or the outdoors group. Despite these non-significant results, the findings still show that acute physical activity played a key role for sustained attention, due to improved speed of processing. Not only are the immediate effects of acute physical activity on sustained attention valuable. In a longer perspective, where physical activity is maintained throughout the life, structural and functional changes in the brain is possibly taking place, advantageous for learning and memory (Barenberg et al., 2011; Cotman et al., 2007; Kramer & Erickson, 2007). Additionally, an interesting finding is that the outdoors group, in total, demonstrated better sustained attention performance following acute physical activity, compared to the indoors group. This was too the group which reported the highest frequency of physical activity the last seven days, indicating that these participants possibly were more physically active compared to the indoors group. Perhaps this might be seen in relation to the notion that frequent physical activity might induce neurological changes in the brain, advantageous for cognitive functioning, as pointed out by Barenberg et al., (2011).

On the other hand, it should not be ignored that the results pointing towards positive effects of acute physical activity on sustained attention, was not striking. The current results confirm what other researchers (e.g., Etnier et al., 1997; Lambourne & Tomporowski, 2010) have found in their studies; the relationship between acute physical activity and cognition remains to be completely understood. Furthermore, it appears that the results of the current study are similar to the findings of the review of Etnier et al., (1997). Etnier et al., (1997) concluded that acute physical activity did not have a significant effect on cognition and demanded more research on the topic. Yet, Lambourne and Tomporowski (2010), in line with the current study, concluded that cognitive task performance following physical activity showed a small to medium improvement, in speed of mental processes. In addition, the researchers reported that cycling compared to running, had a better effect on cognitive performance both during and immediately following physical exertion. Taken Lambourne and Tomporowski's (2010) findings into consideration, this might imply that if cycling instead of running was selected as physical activity in the current study, one could have found different results.

The results of the current study must be seen in relation to the matter that cognitive performance may be impaired or enhanced due to several factors. Some of these factors are the intensity and duration of the physical activity, or at what time the cognitive capacity is being measured following the physical exertion (Lambourne & Tomporowski, 2010). It's conceivable that participants' physical condition level could have affected the degree of tiredness following the physical exertion. This could in turn have negatively influenced cognitive performance, resulting in nonsignificant posttest results. Perhaps sustained attention performance could have been measured later than ten minutes following physical activity, and possibly led to different results.

Furthermore, the duration of the physical activity in the current experiment was set to 30 minutes, which corresponded to the descriptions of acute physical activity, according to Verburgh et al., (2013). However, some studies that are highlighted in the review of Lambourne and Tomporowski (2010), applied a physical activity duration that exceeded 30 minutes. For instance, while Audiffren et al., (2008) used a duration of 40 minutes, Collardeau, Brisswalter and Audiffren (2001) chose to administer 90 minutes of physical activity. Consequently, it's reasonable to believe that one could have found different results by extending the physical activity duration.

The inverted-U theory. The findings of the current study seemed to don't fully support the predictions of the inverted-U theory. This claim is due to the lack of significant improvement of speed of processing following acute moderate intensity physical activity in both groups. In addition, no significant improvement following acute moderate intensity physical activity was shown on accuracy of responding within the indoors group. Therefore, it's not certain that moderate intensity physical activity was the most preferable intensity considering optimal attentional performance following physical activity. On the other hand, it might be argued that the current findings support the inverted-U theory due to the significant improvement on accuracy following acute moderate intensity physical activity, within the outdoors group. Also, the inverted-U theory is in line with the results indicating a slightly improvement on speed of processing following acute moderate intensity physical activity in both groups. On this basis, the findings of the current study can be seen in contrast to the meta-analysis of Chang et al., (2012), which failed to support an inverted-U effect. For a more thorough investigation of the inverted-U theory, it would be advantageous to test several levels of arousal. In other words, a comparison of different physical activity intensities could provide more accurate information about which physical activity intensities is beneficial for sustained attention performance.

***The transient hypofrontality hypothesis*.** The hypofrontality hypothesis focuses on effects on cognition during acute physical activity (Dietrich & Sparling, 2004; Dietrich, 2006). This contrasts with the current study, which was concerned with cognitive effects following acute physical activity. Still, the hypofrontality hypothesis is relevant to the findings of the current study. Considering the hypofrontality hypothesis, it’s conceivable that the non-significant improvements of the current study was due to a downregulation of prefrontal structures. In the current study, the posttest CRT task was conducted within ten minutes following the physical activity part, due to control for arousal levels (Magnie et al., 2000). Thus, it’s likely that a downregulation in prefrontal structures still took place after ten minutes. But, given that downregulation of prefrontal structures constitutes a valid explanation of the findings, one must also recognize sustained attention as a psychological construct which is associated with frontal and parietal cortical areas of the brain (Sarter et al., 2001). This is in contrast with Petersen and Posner (2012) who claim that sustained attention is mostly related to brain stem arousal systems.

Research Question II: Is the change between pretests and posttests of the CRT task in the outdoors group significantly different from the change between pretests and posttests of the CRT task in the indoors group?

The results from the independent-samples t-test suggest that there was no significant difference between the two groups regarding change between pretests and posttests on the CRT task. More specifically, in terms of accuracy of responding, there was no significant difference on change between pretests and posttests in the outdoors group and the indoors group. In terms of speed of reaction times, no significant difference on change between pretests and posttest in the outdoors group and the indoors group was found. This finding indicates that the environment the participants did the physical activity, was not essential in determination of participants’ performance on posttest CRT task. Consequently, the improvement of sustained attention within each group, might be due to a general effect of acute physical activity. Moreover, it's considered as a somewhat surprising finding that participants in the outdoors condition didn't performed significantly better on the CRT task compared to participants in the indoors condition. Since prior studies prove to demonstrate cognitive improvement of interacting with nature, one could expect similar findings of the current study.

For example, Tennessen and Cimprich (1995) found that students showed better abilities of directing attention if they had dormitory windows with natural views compared to if they had dormitory windows with less natural views. This divergences with the current study's findings. Firstly, Tennessen and Cimprich (1995) found that simply a view of nature represented an attention-restoring experience. This contrasts with the current study, which was concerned with the view of nature in combination with physical activity outdoors in natural environments. It's possible that the *perception* of natural environments itself serves a stronger restorative effect on attention, compared to views of nature in combination with physical activity, as in the current study. Secondly, it's likely that natural views from dormitory windows represented a long-term exposure to natural environments since the students probably lived there, in contrast to a 30 minutes' run at the seaside. Thirdly, the fact that only a single measure of sustained attention was applied in the current study, contrasts with Tennessen and Cimprich's (1995) study, that applied both subjective and various objective measures. This possibly made it easier to capture positive effects of nature exposure on several attentional aspects. However, it's challenging to compare the studies as different tests are used to measure different cognitive aspects. In general, this is a challenge in the integration of nature exposure-cognition field and the acute physical activity-cognition field, as there is no consensus on which measure to use.

Furthermore, in disagreement with the current study, Berman et al., (2008) could report improved attentional abilities of walking in nature in contrast to walking downtown. Downtown, and the indoors condition, as in the current study, represents different experimental conditions. Yet, it's fruitful to link the studies as one can assume that both conditions are characterized by built environments, simple stimuli and poor quality of air. In line with the current study, Berman et al., (2008) has included the physical activity aspect of walking, in their study. However, walking is characterized by lower physical activity intensity than running, approximately $\leq$30% VO_{2MAX} (Kamiljo et al., 2009). In light of this, it's likely that walking in contrast to running in natural environments, has a positive effect on attention. It's possible that walking promoted pure presence in nature, and contributed to less focus in the activity itself. Another point from the study of Berman et al., (2008) that is relevant to highlight, is that the walks lasted for 50 minutes, in contrast to a run of 30 minutes, in the current study. The different duration of exposure to natural environments between the studies, might clarify some findings. For instance, it's likely that longer time spent in natural environments give valuable opportunities of immersing oneself with the natural world. In turn, such an experience might work as restoration of attentional capacity. In addition, one can imagine that participants who fitted to the outdoors condition did not gain the maximal potential benefits from the natural environments. This could be due to distractions and stress caused by inspections of the running watch, or the thought of returning to starting area for run.

ART. ART states that natural environments, compared to more neutral environments, have qualities which are beneficial for attentional capacity. This contrasts with the current study's result, which found that there was no significant difference between the groups regarding change between pretests and posttests of the CRT task. To study potential effects the environment has on cognitive functioning, it was essential to make sure that the area applied for the outdoors condition in the current study fitted well with what characterizes a natural environment. Maas and Verheij's (2007) definition of natural environments as both public gardens, parks, forests and trees, is suitable with the characteristics of the seaside path of Ladestien. Nevertheless, it's hard to tell if Ladestien succeeded in meeting Kaplan's (1995) four characteristics of what makes an environment restorative. For example, it might be that participants didn't get the sense of *being away.* Perhaps participants, from earlier periods, did have spent lots of time on the current place, making it not so exciting anymore. In addition, the fact that Ladestien is one of the most popular recreation areas in Trondheim (Trondheim kommune, 2017), implies that it's usually great human activity in the area. This, in combination with the variety of cafes and human interventions, can thus make one feels not *being away.* Another factor that can explain the current results, is the weather conditions during the two days the experiment was conducted at Ladestien. Weather variations is something that ART doesn't accounts for, but is considered as highly relevant for the current study's results. As already mentioned, one of the days the experiment was conducted, was characterized by slightly worse weather than the other day. Yet, the experiment took place in September and the colors of the trees were mostly yellow and orange. It's possible that one could get other findings, if the outdoors experimental condition were done during the summer instead of the autumn. Perhaps distinct colors and temperatures, play an important role for well-being, which in turn can influence attentional performance.

The Norwegian culture of friluftsliv. The findings of the current study might be seen from a cultural perspective, more specifically considering the Norwegian culture of *friluftsliv*. As mentioned, spending time in nature to slow down or to do activities, is a part of Norwegians' identity. Furthermore, the outdoors condition within the current experiment, typified by a planned running session within a particular intensity and period, might be associated with a typical activity of Norwegian *friluftsliv.* To be clear, the outdoors condition of the current experiment is comparable to what Gelter (2000) outlines as *"post-modern" friluftsliv*, defined by sportified outdoors activities, commercialization and a "quick fix" from daily life. It may be considered that the aspect of highly controlled physical activity may have influenced the cognitive performance, measured following the activity part, in an undesirable way. The physical activity part consisting of restrictions regarding duration of physical activity, type of physical activity and intensity, may have been disturbing to some participants. The goal of a nature experience essentially is relaxation and regaining energy. In contrast, it's likely that the participants of the current study were guided towards something different; goal-directed behavior and structured physical activity. As mentioned, probably, the restorative effects on attention is achieved by pure presence and immersion with the natural environment. This corresponds to the description of *"genuine friluftsliv"*. It's exemplified by a strong emotional relationship to the aesthetics and biology of the natural world, and not necessarily the ambition of doing structured physical activity in nature (Gelter, 2000).

Limitations of the Current Study

The current study had several limitations. One limitation was the relatively small sample size. Especially, to generate fruitful and analyzable data, a sample size larger than 20, as in the current study, is often preferred. Thus, this imposes restrictions on generalization. Also, more effort could be done to recruit a more equal distribution of gender. Furthermore, a challenge concerning the implementation of a between-subjects design is the impossibility of maintaining homogeneity across the groups. Therefore, it's possible that a within-subjects design, with the same participants in all experimental conditions, could be more accurate. Additionally, environmental variables as different time of testing during the days constituted a limitation of the current study. This is due to the possibility that participants were more mentally alerted early at the day compared to the afternoon, which could have affected the cognitive performance. In addition, there was a challenge of conducting the experiment in genuine nature. For instance, one could not control for variables as weather, which may be thought to have influenced the results. In contrast, any strictly controlled experiment applying virtual natural environments, enable control of confounding variables. However, genuine natural environments in the current study was preferred to ensure validity. Finally, the study was limited by few measures on sustained attention. Different measures on sustained attention, or various tests to measure numerous aspects of attention, could provide more complementary data on how acute physical activity indoors versus outdoors in natural environments might influence attention. Hence, a weakness of the study was the lack of emotional measures, that could provide information of participants' current mood prior to the conduction of the experiment, as this could have affected the cognitive performance (Ulrich, 1993)

Conclusions and Future Research

The goal of this study was to examine the effects of acute physical activity on sustained attention, indoors versus outdoors in natural environments. In terms of answering research question I, the results showed a slightly improvement in both groups on posttest CRT task, regarding speed of processing. Thus, acute physical activity in general seemed to have a small, but meaningful influence on sustained attention performance. Furthermore, a significant improvement on the posttest on accuracy of responding, was shown in the outdoors group. It's possible that the exposure to natural environments served an attention-restoring experience, which might explain this finding. In respect of research question II, one cannot yet claim that it's more beneficial for sustained attention performance to do acute physical activity outdoors in natural environments compared to indoors. More research is needed to recognize how different environments influence human cognitive functioning. Yet, this study has demonstrated that physical activity still seems to have a slightly positive influence on cognitive functioning.

Regarding future research, it could be relevant to explore how long time any improvement on sustained attention performance lasted following acute physical activity. Future research could for example measure sustained attention performance on participants following 10, 30 and 60 minutes of acute physical activity. By focusing more detailed on the time aspects of sustained attention performance, one could tell if it's likely to achieve optimal cognitive performance immediately following acute physical activity, or perhaps after an hour. Moreover, in another study, by including a comparison of acute physical activity indoors and outdoors in natural environments, one could choose to extend the duration of physical activity in nature. It's possible that *perception* of the natural environment is important for the attention-restoring effect. This means that it's not necessarily compatible to combine moderate intensity physical activity with exposure to natural environments if the goal is improved attentional performance. Moreover, moderate intensity physical activity, as running, might be associated with goal-directed exercise and competition, and may act as a disturbing element for perception of nature. Walking instead of running could to a larger degree promote perception and immersion of the natural environments. This in turn might have the potential of restoring one's attentional capacity, and in case improve attentional performance.

Besides, a greater depth of insight may have been obtained by conducting an experiment with several experimental conditions. It's interpreted as there is a lack of understanding regarding what characteristics of natural environments that it's associated with potential improved cognitive performance following nature exposure. Consequently, future research might focus more specifically on what exact characteristics of different environments both indoors and outdoors, that can have a potential effect on human cognition. This could be done by comparing exposure to untouched wilderness with a well-known recreation area, as Ladestien.

This study has provided valuable knowledge by integrating the fields of cognitive effects of nature exposure-cognition, and acute physical activity-cognition interactions. The current study, and generally research that revolves around the potential cognitive benefits of physical activity and nature exposure, have practical implications. For instance, such research might play a role in implementing programs in schools and in working life. Demands of physical activity during a school day, would be highly relevant, as a regular school day is characterized by amounts of sedentary behavior. Besides, the field of urban planning may benefit from such research, with respect to establishing activity zones or green areas in urban cities.

References

Audiffren, M., Tomporowski, P. D., & Zagrodnik, J. (2008). Acute aerobic exercise and information processing: energizing motor processes during a choice reaction time task. *Act Psychologica*, *129*(3), 410-419. doi: http://dx.doi.org/10.1016/j.actpsy.2008.09.006

Barenberg, J., Berse, T., & Dutke, S. (2011). Executive functions in learning processes: do they benefit from physical activity? *Educational Research Review*, *6*(3), 208-222. doi: http://dx.doi.org/10.1016/j.edurev.2011.04.002

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science*, *19*(12), 1207-1212. doi: https://doi.org/10.1111/j.1467-9280.2008.02225.x

Berman, M. G., Kross, E., Krpan, K. M., Askren, M. K., Burson, A., Deldin, P. J., . . . Jonides, J. (2012). Interacting with nature improves cognition and affect for individuals with depression. *Journal of Affective Disorders*, *140*(3), 300-305. doi: http://dx.doi.org/10.1016/j.jad.2012.03.012

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology*, *25*(3), 249-259. doi: http://dx.doi.org/10.1016/j.jenvp.2005.07.001

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*, *10*(1), 1-10. doi: 10.1186/1471-2458-10-456

Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health. *Annals of the New York Academy of Sciences*, *1249*(1), 118-136. doi: 10.1111/j.1749-6632.2011.06400.x

Brisswalter, J., Collardeau, M., & René, A. (2002). Effects of acute physical exercise characteristics on cognitive performance. *Sports Medicine*, *32*(9), 555-566. doi: 10.2165/00007256-200232090-00002

Bruya, B. (2010). *Effortless attention: A new perspective in the cognitive science of attention and action.* Cambridge: Massachusetts Institute of Technology.

Cabeza, R., & Nyberg, L. (2000). Imaging cognition II: An empirical review of 275 PET and fMRI studies. *Journal of Cognitive Neuroscience*, *12*(1), 1-47. doi: 10.1162/08989290051137585

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126-131. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1424733/pdf/pubhealthrep00100-0016.pdf

Chang, C. Y., Hammitt, W. E., Chen, P. K., Machnik, L., & Su, W. C. (2008). Psychophysiological responses and restorative values of natural environments in Taiwan. *Landscape and Urban Planning*, *85*(2), 79-84. doi: http://dx.doi.org/10.1016/j.landurbplan.2007.09.010

Chang, Y. K., Labban, J. D., Gapin, J. I., & Etnier, J. L. (2012). The effects of acute exercise on cognitive performance: a meta-analysis. *Brain Research*, *1453*, 87-101. doi: http://dx.doi.org/10.1016/j.brainres.2012.02.068

Cohen, R. A. (1993). *Neuropsychology of Attention.* New York: Plenum. Retrieved from http://download.springer.com/static/pdf/323/bok%253A978-0-387-72639-7.pdf?originUrl=http%3A%2F%2Flink.springer.com%2Fbook%2F10.1007%2F978-0-387-72639-7&token2=exp=1486893132~acl=%2Fstatic%2Fpdf%2F323%2Fbok%25253A978-0-387-72639-7.pdf%3ForiginUrl%3Dhttp%253A%252F%252Flink.springer.com%252Fbook%252F10.1007%252F978-0-387-72639-7*~hmac=3e4c0f846961d42d7818bfd0981730631da16801c07c348b43112d147e0a6edb

Collardeau, M., Brisswalter, J., & Audiffren, M. (2001). Effects of a prolonged run on simple reaction time of well trained runners. *Perceptual and Motor Skills*, *93*(3), 679-689. doi: https://doi.org/10.2466/pms.2001.93.3.679

Conners, C. K., Epstein, J. N., Angold, A., & Klaric, J. (2003). Continuous performance test performance in a normative epidemiological sample. *Journal of Abnormal Child Psychology*, *31*(5), 555-562. doi: 10.1023/A:1025457300409

Cotman, C. W., Berchtold, N. C., & Christie, L. A. (2007). Exercise builds brain health: key roles of growth factor cascades and inflammation. *Trends in Neurosciences*, *30*(9), 464-472. doi: http://dx.doi.org/10.1016/j.tins.2007.06.011

Craig, C. L., Marshall, A. L., Sjöström, M., Baumann, A. E., Booth, M. L., Ainsworth, B. A., . . . Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise*, *195*, 1381-1395. doi: 10.1249/01.MSS.0000078924.61453.FB

Davranche, K., & Audiffren, M. (2004). Facilitating effects of exercise on information processing. *Journal of Sports Sciences*, *22*(5), 419-428. doi: 10.1080/02640410410001675289

Davranche, K., Audiffren, M., & Denjean, A. (2006). A distributional analysis of the effect of physical exercise on a choice reaction time task. *Journal of Sports Sciences, 24*(3), 323-329. doi: 10.1080/02640410500132165

Deary, I. J., Liewald, D., & Nissan, J. (2011). A free, easy-to-use, computer-based simple and four-choice reaction time programme: the Deary-Liewald reaction time task. *Behavior Research Methods*, *43*(1), 258-268. doi: 10.3758/s13428-010-0024-1

Diamond, A. (2006). The early development of executive functions. In E. Bialystok & F.I.M Craik (Eds.), *Lifespan Cognition: Mechanisms of Change* (pp. 70-95). New York: Oxford University Press. Retrieved from https://books.google.no/books?id=nt6uqjnGW_8C&lpg=PA70&ots=7CgDA8Sdja&dq

Diamond, A. (2013). Executive functions. *Annual review of psychology*, *64*, 135-168. doi: 10.1146/annurev-psych-113011-143750

Dietrich, A. (2003). Functional neuroanatomy of altered states of consciousness: the transient hypofrontality hypothesis. *Consciousness and Cognition*, *12*(2), 231-256. doi: http://dx.doi.org/10.1016/S1053-8100(02)00046-6

Dietrich, A. (2006). Transient hypofrontality as a mechanism for the psychological effects of exercise. *Psychiatry Research*, *145*(1), 79-83. doi: http://dx.doi.org/10.1016/j.psychres.2005.07.033

Dietrich, A., & Sparling, P. B. (2004). Endurance exercise selectively impairs prefrontal-dependent cognition. *Brain and Cognition*, *55*(3), 516-524. doi: http://dx.doi.org/10.1016/j.bandc.2004.03.002

Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review, 66*(3), 183-201. doi: http://dx.doi.org/10.1037/h0047707

Etnier, J. L., Salazar, W., Landers, D. M., Petruzzello, S. J., Han, M., & Nowell, P. (1997). The influence of physical fitness and exercise upon cognitive functioning: a meta-analysis. *Journal of Sport and Exercise Psychology*, *19*(3), 249-277. doi: http://dx.doi.org/10.1123/jsep.19.3.249

Ferris, L. T., Williams, J. S., & Shen, C. L. (2007). The effect of acute exercise on serum brain-derived neurotrophic factor levels and cognitive function. *Medicine and Science in Sports and Exercise*, *39*(4), 728. doi: 10.1249/mss.0b013e31802f04c7

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage.

Gelter, H. (2000). Friluftsliv: The Scandinavian philosophy of outdoor life. *Canadian Journal of Environmental Education* (CJEE), 5(1), 77-92. Retrieved from https://cjee.lakeheadu.ca/article/view/302/803

Gelter, H. (2010). Friluftsliv as slow and peak experiences in the transmodern society. *Norwegian Journal of Friluftsliv*, 1-22. doi: 7bf41c40-d162-11df-a707-000ea68e967b

Guizani, S. M., Bouzaouach, I., Tenenbaum, G., & Kheder, A. B. (2006). Simple and choice reaction times under varying levels of physical load in high skilled fencers. *Journal of Sports Medicine and Physical Fitness*, *46*(2), 344. Retrieved from https://search.proquest.com/docview/202677257?accountid=12870

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology*, *23*(2), 109-123. doi: http://dx.doi.org/10.1016/S0272-4944(02)00109-3

Hartig, T. (2007). Three steps to understanding restorative environments as health resources. In C.W. Thompson & P. Travlou (Eds.), *Open Space: People Space* (pp. 163-179). London: Taylor & Francis. Retrieved from https://books.google.no/books?id=8ct5AgAAQBAJ&lpg=PA163&ots=2IXRoYlje4&dq=hartig%2C%202007.%20three%20steps%20to%20understanding%20restorative%20environments%20as%20health%20resources%20&lr&hl=no&pg=PA163#v=onepage&q=hartig,%202007.%20three%20steps%20to%20understanding%20restorative%20environments%20as%20health%20resources&f=false

Henriksson, J., & Sundberg, C. J. (2008). 1. Generelle effecter av fysisk aktivitet. In Roald Bahr (Eds.), *Aktivitetshåndboken. Fysisk aktivitet i forebygging og behandling* (p. 8-36). Retrieved from https://helsedirektoratet.no/Lists/Publikasjoner/Attachments/463/Aktivitetshandboken-IS-1592.pdf

Herring, M. P., O'connor, P. J., & Dishman, R. K. (2010). The effect of exercise training on anxiety symptoms among patients: a systematic review. *Archives of Internal Medicine, 170*(4), 321-331. doi: 10.1001/archinternmed.2009.530

Hug, S. M., Hartig, T., Hansmann, R., Seeland, K., & Hornung, R. (2009). Restorative qualities of indoor and outdoor exercise settings as predictors of exercise frequency. *Health & Place*, *15*(4), 971-980. doi: http://dx.doi.org/10.1016/j.healthplace.2009.03.002

Kahn, P. H. (1997). Developmental psychology and the biophilia hypothesis: Children's affiliation with nature. *Developmental Review*, *17*(1), 1-61. doi: https://doi.org/10.1006/drev.1996.0430

Kamijo, K., Hayashi, Y., Sakai, T., Yahiro, T., Tanaka, K., & Nishihira, Y. (2009). Acute effects of aerobic exercise on cognitive function in older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 64*(3), 356-363. doi: https://doi.org/10.1093/geronb/gbp030

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge: Cambridge University Press.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*(3), 169-182. doi: http://dx.doi.org/10.1016/0272-4944(95)90001-2

Kjellgren, A., & Buhrkall, H. (2010). A comparison of the restorative effect of a natural environment with that of a simulated natural environment. *Journal of Environmental Psychology*, *30*(4), 464-472. doi: http://dx.doi.org/10.1016/j.jenvp.2010.01.011

Kramer, A. F., & Erickson, K. I. (2007). Capitalizing on cortical plasticity: influence of physical activity on cognition and brain function. *Trends in Cognitive Sciences*, *11*(8), 342-348. doi: http://dx.doi.org/10.1016/j.tics.2007.06.009

Laerd Statistics. (2017, 20.04). Testing for normality using SPSS statistics. Retrieved from https://statistics.laerd.com/spss-tutorials/testing-for-normality-using-spss-statistics.php

Lambourne, K., & Tomporowski, P. (2010). The effect of exercise-induced arousal on cognitive task performance: a meta-regression analysis. *Brain Research*, *1341*, 12-24. doi: http://dx.doi.org/10.1016/j.brainres.2010.03.091

Maas, J., & Verheij, R. A. (2007). Are health benefits of physical activity in natural environments used in primary care by general practitioners in The Netherlands?. *Urban Forestry & Urban Greening*, *6*(4), 227-233. doi: 10.1016/j.ufug.2007.03.003

Magnié, M. N., Bermon, S., Martin, F., Madany-Lounis, M., Suisse, G., Muhammad, W., & Dolisi, C. (2000). P300, N400, aerobic fitness, and maximal aerobic exercise. *Psychophysiology*, *37*(3), 369-377. doi: 10.1111/1469-8986.3730369

Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, *24*(4), 503-515. doi: https://doi.org/10.1016/j.jenvp.2004.10.001

McMorris, T. (2009). Exercise and cognitive function: a neuroendocrinological explanation.

In McMorris, T., Tomporowski, P. & Audiffren, M. (Red.), *Exercise and Cognitive Function*. (1, 41-68). Hoboken, GB: Wiley. doi: 10.1002/9780470740668.ch2van der

McMorris, T. (Ed.). (2016). *Exercise-Cognition Interaction: Neuroscience Perspectives*. Academic Press.

McMorris, T., & Hale, B. J. (2012). Differential effects of differing intensities of acute exercise on speed and accuracy of cognition: a meta-analytical investigation. *Brain and Cognition*, *80*(3), 338-351. doi: http://dx.doi.org/10.1016/j.bandc.2012.09.001

Nes, B. M., Janszky, I., Wisløff, U., Støylen, A., & Karlsen, T. (2013). Age-predicted maximal heart rate in healthy subjects: The HUNT Fitness Study. *Scandinavian Journal of Medicine & Science in Sports*, *23*(6), 697-704. doi: 10.1111/j.1600-0838.2012.01445.x

Niet, A. G., Smith, J., Scherder, E. J., Oosterlaan, J., Hartman, E., & Visscher, C. (2015). Associations between daily physical activity and executive functioning in primary school-aged children. *Journal of Science and Medicine in Sport*, *18*(6), 673-677. doi: http://dx.doi.org/10.1016/j.jsams.2014.09.006

Ortega, F. B., Ruiz, J. R., Castillo, M. J., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: a powerful marker of health. *International Journal of Obesity*, *32*(1), 1-11. doi: 10.1038/sj.ijo.0803774

Pedersen, B. K., & Saltin, B. (2015). Exercise as medicine–evidence for prescribing exercise as therapy in 26 different chronic diseases. *Scandinavian Journal of Medicine & Science in Sports*, *25*(S3), 1-72. doi: 10.1111/sms.12581

Pesce, C., & Audiffren, M. (2011). Does acute exercise switch off switch costs? A study with younger and older athletes. *Journal of Sport and Exercise Psychology*, *33*(5), 609-626. doi: http://dx.doi.org/10.1123/jsep.33.5.609

Petersen, S. E., & Posner, M. I. (2012). The attention system of the human brain: 20 years after. *Annual Review of Neuroscience, 35*, 73-89. doi: 10.1146/annurev-neuro-062111-150525

Posner, M. I. (1978). *Chronometric explorations of mind*. Retrieved from http://lolita.unice.fr/~scheer/cogsci/Posner%2081%20-%20Chronometric%20explorations%20of%20mind.pdf

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*(1), 25-42. doi: o I 47-006Xj90j030 1-0025$02.00

Pribram, K. H., & McGuinness, D. (1975). Arousal, activation and effort in the control of attention. *Psychological Review*, *82*(2), 116-149. doi:

http://dx.doi.org/10.1037/h0076780

Ramstad, T. F. (2014). Utvikling av eksekutivfunksjoner og læring i åpne skoler. In H. Sigmundsson (Eds.), *Læringsvansker* (pp. 161-194). Bergen: Fagbokforlaget.

Ratey, J. J., & Loehr, J. E. (2011). The positive impact of physical activity on cognition during adulthood: a review of underlying mechanisms, evidence and recommendations. *Reviews in the Neurosciences, 22*(2), 171-185. doi: https://doi.org/10.1515/rns.2011.017

Sarter, M., Givens, B., & Bruno, J. P. (2001). The cognitive neuroscience of sustained attention: where top-down meets bottom-up. *Brain Research Reviews*, *35*(2), 146-160. doi: http://dx.doi.org/10.1016/S0165-0173(01)00044-3

St.meld. nr. 18 (2015-2016). (2016). *Friluftsliv. Natur som kilde til helse og livskvalitet.* Retrieved from https://www.regjeringen.no/contentassets/9147361515a74ec8822c8dac5f43a95a/no/pdfs/stm201520160018000dddpdfs.pdf

Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*, *72*(2), 271-324. doi: 10.1111/j.0022-3506.2004.00263.x

Tennessen, C. M., & Cimprich, B. (1995). Views to nature: Effects on attention. *Journal of Environmental Psychology*, *15*(1), 77-85. doi: http://dx.doi.org/10.1016/0272-4944(95)90016-0

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M. H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental Science & Technology*, *45*(5), 1761-1772. doi: dx.doi.org/10.1021/es102947t

Tomporowski, P. D. (2003). Cognitive and behavioral responses to acute exercise in youths: A review. *Pediatric Exercise Science*, *15*(4), 348-359. doi: http://dx.doi.org/10.1123/pes.15.4.348

Tomporowski, P. D., & Ellis, N. R. (1986). Effects of exercise on cognitive processes: A review. *Psychological Bulletin*, *99*(3), 338-346. doi: http://dx.doi.org/10.1037/0033-2909.99.3.338

Trejo, J. L., Carro, E., & Torres-Alemán, I. (2001). Circulating insulin-like growth factor I mediates exercise-induced increases in the number of new neurons in the adult hippocampus. *Journal of Neuroscience*, *21*(5), 1628-1634. doi: 0270-6474/01/211628-

07$15.00/0

Trondheim kommune. (2017, 10.04). Ladestien. Retrieved from https://www.trondheim.kommune.no/ladestien/

Ulrich, R. (1984). View through a window may influence recovery. *Science, 224*(4647), 224-225. doi: 10.1126/science.6143402

United Nations, Department of Economic and Social Affairs, Population Division (2014). *World Urbanization Prospects: The 2014 Revision, Highlights.* Retrieved from https://esa.un.org/unpd/wup/publications/files/wup2014-highlights.Pdf

Verburgh, L., Königs, M., Scherder, E. J., & Oosterlaan, J. (2013). Physical exercise and executive functions in preadolescent children, adolescents and young adults: a meta-analysis. *British Journal of Sports Medicine*, bjsports-2012. doi: http://dx.doi.org/10.1136/bjsports-2012-091441

Vissing, J., Andersen, M., & Diemer, N. H. (1996). Exercise-induced changes in local cerebral glucose utilization in the rat. *Journal of Cerebral Blood Flow & Metabolism*, *16*(4), 729-736. doi: https://doi.org/10.1097/00004647-199607000-00025

Wisløff, U., Støylen, A., Loennechen, J. P., Bruvold, M., Rognmo, Ø., Haram, P. M., ... & Videm, V. (2007). Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients. *Circulation*, *115*(24), 3086-3094. doi: 10.1161/CIRCULATIONAHA.106.675041

World Health Organization (2016). Obesity and overweight. Retrieved from http://www.who.int/mediacentre/factsheets/fs311/en/

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology*, *18*(5), 459-482. doi: 10.1002/cne.920180503

Appendix A

Authorization from Norwegian Social Sciences Data Service (NSD).

NSD

Hermundur Sigmundsson
Psykologisk institutt NTNU

7491 TRONDHEIM

Vår dato: 24.10.2016 Vår ref: 50175 / 3 / AGH Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 23.09.2016. Meldingen gjelder prosjektet:

50175	*Fysisk aktivitet i naturomgivelser sammenlignet med fysisk aktivitet innendørs og hvilken effekt dette har på oppmerksomhet/ konsentrasjon. Dette beskriver prosjektets innhold i grove trekk, men det kan hende ordlyden på oppgaven vil være annerledes når den er ferdig.*
Behandlingsansvarlig	*NTNU, ved institusjonens øverste leder*
Daglig ansvarlig	*Hermundur Sigmundsson*
Student	*Ane Oline Roland Roland*

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, ombudets 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/meldeplikt/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, 01.05.2017, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Kjersti Haugstvedt

Agnete Hessevik

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

NSD – Norsk senter for forskningsdata AS Harald Hårfagres gate 29 Tel: +47-55 58 21 17 nsd@nsd.no Org.nr. 985 321 884
NSD Norwegian Centre for Research Data NO-5007 Bergen, NORWAY Faks: +47-55 58 96 50 www.nsd.no

Appendix B

Written informed consent.

Informasjonsskriv

«Effekt på oppmerksomhet ved fysisk aktivitet innendørs versus utendørs fysisk aktivitet»

Bakgrunn og formål
Dette forskningsprosjektet utgjør en masterstudie som gjennomføres på psykologisk institutt ved NTNU. Fra tidligere forskning vet vi at fysisk aktivitet kan være forbundet med god kognitiv prestasjon. Formålet med studien er å undersøke om fysisk aktivitet utendørs i naturomgivelser versus innendørs fysisk aktivitet har ulik effekt på oppmerksomhet. I tillegg ønsker studien å undersøke hvorvidt ulike naturomgivelser spiller en rolle for oppmerksomheten vår. Vil fysisk aktivitet i fargerike og kuperte naturomgivelser påvirke vår kognitive prestasjon annerledes i forhold til for eksempel fysisk aktivitet i et hvitt vinterlandskap? Det er økt interesse for å forstå hvilken innflytelse naturen har på mennesker, både når det gjelder psykisk helse og kognitiv prestasjon. Målet er at denne studien kan bidra med kunnskap hva gjelder det sistnevnte.

Studien benytter between-subjects design. Dette er en form for eksperimentelt design hvor deltakerne blir delt inn i ulike grupper og plasseres i ulike betingelser. Dette eksperimentet har tre betingelser: 1. fysisk aktivitet innendørs, 2. fysisk aktivitet utendørs (Estenstadmarka, vinter), og 3. fysisk aktivitet utendørs (Ladestien, høst).

Utvalget består av studenter. Rekrutteringsprosessen foregikk ved at det ble hengt opp informasjon om studien på NTNU Dragvoll. Informasjonsark om studien ble også lagt i postkasser på studentbyer i Trondheim, og det ble kommunisert muntlig om studien i blant annet forelesninger. Noen av studentene som takket ja til å delta, ble videre spurt om å informere venner om studien.

Hva innebærer deltakelse i studien?
Det er frivillig å delta i prosjektet. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på neste side. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke.

Deltakeren vil bli bedt om å besvare to korte spørreskjema og ta en oppmerksomhetstest. Deretter skal det gjennomføres fysisk aktivitet på omtrent 30 minutter innendørs på en tredemølle eller utendørs i naturomgivelser. Eksperimentet avsluttes innendørs hvor oppmerksomhetstesten tas igjen. Deltakeren vil bli tilfeldig valgt til én av de tre betingelsene. En pulsklokke vil bli tildelt deltakerne slik at deltakeren selv kan følge med på sin egen puls. Dette gjøres fordi det er ønskelig at alle deltakerne skal ha noenlunde lik puls under den fysiske øvelsen, da for store variasjoner i puls kan påvirke resultatene. Det er anslått at hele eksperimentet vil ta omtrent 1-1 ½ time.

Hva skjer med informasjonen om deg?
Alle personopplysninger vil bli behandlet konfidensielt. En kode knytter deg til dine opplysninger gjennom en navneliste. På denne måten vil datamaterialet anonymiseres og deltakerne vil ikke kunne gjenkjennes i en eventuell publikasjon. Det er jeg, min veileder Hermundur Sigmundsson, og min biveileder Håvard Lorås, som vil ha tilgang til datamaterialet. Mailer og eventuelle tekstmeldinger mellom prosjektleder og deltaker vil bli slettet med en gang eksperimentet er gjennomført. Prosjektet skal avsluttes 01.05.17. Datamaterialet anonymiseres ved prosjektslutt.

Frivillig deltakelse
Det er frivillig å delta i studien, og du kan når som helst trekke ditt samtykke uten å oppgi noen grunn. Dersom du trekker deg, vil alle opplysninger om deg bli anonymisert.

Dersom du har spørsmål om studien, ta kontakt med meg, Ane Oline Roland, mobil: 99152874 / E-post: aneor@stud.ntnu.no/ aneoroland@gmail.com. Du kan også ta kontakt med min veileder Hermundur Sigmundsson, E-post: hermundur.sigmundsson@ntnu.no.

Studien er meldt til Personvernombudet for forskning, NSD - Norsk senter for forskningsdata AS.

Samtykke til deltakelse i studien

Jeg har mottatt informasjon om studien, og er villig til å delta

---

Appendix C

Picture from the attention task part in the room at Dragvoll Sports Center.

Appendix D

View from the room used in the attention task part near Ladestien.

Appendix E

Questionnaire.

Registreringsnummer: __________ Dato: __________

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (IPAQ)

De følgende spørsmålene handler om fysisk aktivitet. Vi er interessert i å vite hvilke former for fysisk aktivitet du driver med i det daglige. Spørsmålene innbefatter tiden du har vært i fysisk aktivitet de siste 7 dagene. Svar på spørsmålene selv om du ikke anser deg for å være en aktiv person. Inkluder alle aktiviteter som både arbeid, når du beveger deg fra sted til sted, husarbeid, hagearbeid, fritidsaktiviteter og planlagt trening.

Når du svarer på spørsmålene:

Meget anstrengende – er fysisk aktivitet som får deg til å puste *mye mer* enn vanlig
Middels anstrengende – er fysisk aktivitet som får deg til å puste *litt mer* enn vanlig

Det er kun aktiviteter som varer **minst 10 minutter i strekk** som skal rapporteres

1a) Hvor mange dager i løpet av de siste 7 dager har du drevet med *meget anstrengende* fysiske aktiviteter som tunge løft, gravearbeid, aerobics eller sykle fort? Tenk bare på aktiviteter som varer *minst 10 minutter i strekk*

Dager per uke

Ingen (gå til spørsmål 2a)

1b) På en vanlig dag hvor du utførte *meget anstrengende* fysiske aktiviteter, hvor lang tid brukte du da på dette?

Timer Minutter Vet ikke/husker ikke

2a) Hvor mange dager i løpet av de siste 7 dager har du drevet med *middels anstrengende* fysiske aktiviteter som å bære lette ting, sykle eller jogge i moderat tempo eller mosjonstennis? Ikke ta med gange, det kommer i neste spørsmål.

Dager per uke

Ingen (gå til spørsmål 3a)

Snu arket

2b) På en vanlig dag hvor du utførte *middels anstrengende* fysiske aktiviteter, hvor lang tid brukte du da på dette?

Timer   Minutter   Vet ikke/husker ikke

3a) Hvor mange dager i løpet av de siste 7 dager, *gikk du minst 10 minutter* i strekk for å komme deg fra ett sted til et annet? Dette inkluderer gange på jobb og hjemme, gange til buss, eller gange som du gjør på tur eller som trening i fritiden

Dager per uke

Ingen (gå til spørsmål 4)

3b) På en vanlig dag hvor du *gikk* for å komme deg fra et sted til et annet, hvor lang tid brukte du da totalt på å gå?

Timer   Minutter   Vet ikke/husker ikke

4) Dette spørsmålet omfatter all tid du tilbringer i ro (*sittende*) på jobb, hjemme, på kurs, og på fritiden. Det kan være tiden du sitter ved et arbeidsbord, hos venner, mens du leser eller ligger for å se på TV.

I løpet av de siste 7 dager, hvor land tid brukte du vanligvis totalt på å sitte på en vanlig hverdag?

Timer   Minutter   Vet ikke/husker ikke

Appendix F

Questionnaire.

The Connectedness to Nature Scale (CNS) (Mayer, McPherson, & Frantz, 2004).

Please answer each of these questions in terms of *the way you generally feel*. There are no right or wrong answers. Using the following scale, in the space provided next to each question simply state as honestly and candidly as you can what you are presently experiencing.

1	2	3	4	5
Strongly disagree		Neutral		Strongly agree

____1. I often feel a sense of oneness with the natural world around me.
____2. I think of the natural world as a community to which I belong.
____3. I recognize and appreciate the intelligence of other living organisms.
____4. I often feel disconnected from nature.
____5. When I think of my life, I imagine myself to be part of a larger cyclical process of living.
____6. I often feel a kinship with animals and plants.
____7. I feel as though I belong to the Earth as equally as it belongs to me.
____8. I have a deep understanding of how my actions affect the natural world.
____9. I often feel part of the web of life.
____10. I feel that all inhabitants of Earth, human, and nonhuman, share a common 'life force'.
____11. Like a tree can be part of a forest, I feel embedded within the broader natural world.
____12. When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.
____13. I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.
____14. My personal welfare is independent of the welfare of the natural world.