Tampere University

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Everyday Physical Activity in Natural Settings and Subjective Well-Being

Direct Connections and Psychological Mediators

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ACADEMIC DISSERTATION
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Tytti Pasanen

ABSTRACT

Physical activity in natural environments may alleviate stress and enhance mood, both of which are closely connected to longer-term human well-being. From the psychological point of view, these so called 'restorative effects' of contact with natural outdoor environments have been explained by two theories emphasising either attention restoration or psycho-physiological stress reduction. Most of the research on visits to different types of environments and human well-being, however, has focused on accessibility and environmental qualities conducive to restoration. Less attention has been paid to psychological aspects such as motives, attentional focus, and engagement with the environment. Furthermore, most research comparing the beneficial effects of physical activity in natural and built environments has been conducted in experimental settings. The applicability of the results of such studies, claiming greater benefit from physical activity in natural outdoor settings than indoors or in built environment, has not been established in everyday life when the activity and its setting can be freely chosen.

This thesis contributes to these discussions by analysing associations between everyday visits to natural settings and mood, restoration, and subjective well-being outcomes, and their psychological mediators. Studies 1-3 are correlational and they are based on Finnish survey datasets, whereas Study 4 summarises two field experiments in a mixed/coniferous forest and an urban park. Analytical methods are different variations of structural equation modelling, comprising several explanatory variables, outcomes, and mediators (when applicable).

The results from Study 1 showed that more frequent physical activity in natural settings was connected to better emotional well-being and better general health, even when controlling for a number of known confounders. More frequent physical activity in built outdoor settings was, likewise, associated with better general health but not with emotional well-being. Physical activity indoors showed no connections to these outcomes.

Study 2, comparing single bouts of physical activity in natural, indoor, and built outdoor settings, found that restorativeness was rated slightly greater in natural settings, while indoor physical activity was associated with better evaluations of self-confidence. However, recalled restoration did not explain the positive association

between the weekly frequency of physical activity in natural settings and emotional well-being.

Regarding visits to natural settings in particular, in Study 3, recalled motives prior to and attentional focus during the most recent visit to nature explained substantial shares of post-visit restoration and emotional well-being. The motive to reduce stress was connected to greater and the motive to be alone was connected to lower post-visit restoration and emotional well-being. In terms of attentional focus during the visit, focusing on the environment and one's own thoughts and activities, but not on other people, correlated with greater restoration and better emotional well-being.

In the two field experiments conducted for Study 4, walking 4–6 kilometres in natural settings resulted in greater restoration and more positive mood, regardless of whether participants conducted psychological tasks during the walk or not. However, there were some differences in changes in sustained attention but these were mostly between the different types of tasks during the walk.

Overall, these results complement and corroborate experimental studies showing enhancement of mood and restoration following various types of nature visits. They also highlight the important role of psychological aspects such as motivation, attentional focus, and engagement with the environment, which have received less attention in applied research. Future investigations in these topics are encouraged.

TIIVISTELMÄ

Luontoympäristöjen läheisyys voi vähentää stressiä ja kannustaa liikkumaan. Nämä tekijät puolestaan ovat yhteydessä pidempiaikaiseen hyvinvointiin. Ympäristöpsykologian tutkimuksessa luontoympäristöille 'altistumisen' hyvinvointiyhteyksiä on selitetty niin sanotulla elpymisellä, jota on lähestytty kahdesta teoreettisesta viitekehyksestä. Toinen näistä painottaa tarkkaavuuden elpymistä ja toinen psykofyysistä stressin vähenemistä. Valtaosa erilaisille ympäristöille altistumista ja hyvinvointia käsittelevästä tutkimuksesta on keskittynyt (luonto)ympäristöjen saavutettavuuteen ja sellaisiin fyysisiin ominaisuuksiin, jotka tukevat elpymistä. Vähemmälle huomiolle on jäänyt yksilöiden psykologiset tekijät kuten motiivit, huomion suuntautuminen ja vuorovaikutus ympäristön kanssa. Lisäksi valtaosa tutkimuksesta, joka vertailee liikkumisen hyvinvointivaikutuksia rakennetuissa ja luontoympäristöissä, on kokeellisia. Vaikka niiden tulokset viittaavat siihen, että luontoympäristö tuo pienen lisäarvon liikunnan tunnettuihin hyvinvointivaikutuksiin, ei tiedetä pätevätkö samat tulokset jokapäiväisessä elämässä, jolloin sekä liikuntamuoto että sen harrastuspaikka on itse valittu.

Tämä väitöskirja osallistuu aiheen tutkimukseen tarkastelemalla jokapäiväisten luontokäyntien suhdetta mielialaan, elpymiseen ja hyvinvointiin, ja psykologisia tekijöitä jotka selittävät näitä suhteita. Osatutkimukset 1-3 ovat korrelatiivisia ja perustuvat suomalaisiin kyselyaineistoihin. Osatutkimus 4 tiivistää kahden kenttäkokeen tulokset, joissa osallistujat kävelivät joko metsässä tai kaupunkipuistossa. Kaikissa tutkimuksissa menetelminä käytetään rakenneyhtälömallinnusta, joissa samassa mallissa voidaan tarkastella useampia selittäviä tekijöitä, riippuvia muuttujia ja mediaattoreita (soveltuvin osin).

Ensimmäisessä osatutkimuksessa luontoympäristöissä liikkumisen useus selitti parempaa emotionaalista hyvinvointia sekä koettua terveyttä, vaikka useita tunnettuja hyvinvointia ja liikuntaa selittäviä tekijöitä oli vakioitu. Rakennetussa ulkoympäristöissä liikkumisen useus oli yhteydessä parempaan koettuun terveyteen muttei emotionaaliseen hyvinvointiin. Sisäliikunnalla ei vastaavia yhteyksiä ollut.

Toisessa osatutkimuksessa tarkasteltiin viimeisintä liikuntakertaa joko luonto-, sisä- tai rakennetussa ulkoympäristössä. Elpyminen oli keskimäärin hieman suurempaa luontoliikunnan jälkeen, mutta jotkin osa-alueet kuten kokemus

itsevarmuudesta oli suurempaa sisäliikunnan jälkeen. Elpymiskokemukset eivät kuitenkaan selittäneet sitä, miksi luontoliikunnalla on yhteys pidempiaikaiseen emotionaaliseen hyvinvointiin.

Kolmas osatutkimus tarkasteli pelkästään luontokäyntejä. Motiivit ja huomion kohteet viimeisimmällä luontokäynnillä selittivät merkittävää osaa käynnin jälkeisestä elpymisestä ja hyvinvoinnista. Mitä suurempi tarve vähentää stressiä, sitä suurempaa oli koettu elpyminen ja hyvinvointi käynnin jälkeen, kun taas toive olla yksin oli yhteydessä matalampaan elpymiseen ja hyvinvointiin. Huomion kohdistus omiin tunteisiin/ajatuksiin, ympäristöön sekä toimintaan (muttei toisiin ihmisiin) olivat kaikki yhteydessä korkeampaan elpymiseen ja hyvinvointiin.

Neljännessä osatutkimuksessa havaittiin, että 4-6 kilometrin kävely luonnossa lisäsi elpymistä ja positiivista mielialaa yhtä lailla riippumatta siitä, tekivätkö osallistujat elpymis- tai muita psykologisia harjoitteita kävelyn aikana vai eivät. Sillä, millaisia harjoitteita teki, oli kuitenkin pieni yhteys tarkkaavuuden ylläpitoon.

Kokonaisuudessaan tulokset täydentävät ja tukevat kokeellisia tutkimustuloksia, joissa hyvin monenlaisten luontoaltistusten on löydetty parantavan mielialaa ja lisäävän elpymistä. Tuloksissa mielialan ja hyvinvoinnin kannalta näyttäytyivät tärkeinä myös psykologiset tekijät kuten motiivit, huomion kohdistus ja vuorovaikutus ympäristön kanssa, joita on tutkittu vähemmän. Tulokset ovat alustavia ja ne kannustavat selvittämään tarkemmin psykologisten tekijöiden yhteyttä elpymiskokemuksiin.

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ABBREVIATIONS

ART	Attention Restoration Theory
CI	Confidence Interval
CFI	Comparative Fit Index
ESEM	Exploratory Structural Equation Modeling
PA	Physical Activity
RMSEA	Root Mean Square Error of Approximation
ROS	Restoration Outcome Scale
RT	Response Time
SART	Sustained Attention to Respond Task
SDRT	Standard Deviation of Response Time
SEM	Structural Equation Modeling
SRMR	Standardized Root Mean Square Residual
SRT	Stress Reduction Theory
TLI	Tucker-Lewis Fit Index

ORIGINAL PUBLICATIONS

I Pasanen, T., Tyrväinen, L., Korpela, K. (2014). The relationship between perceived well-being and physical activity indoors, outdoors in built environments, and outdoors in nature. Applied Psychology: Health and Well-Being, 6(3), 324-346.

II Pasanen, T., Ojala, A., Tyrväinen, L., Korpela, K. (2018). Restoration, well-being, and everyday physical activity in indoor, built outdoor and natural outdoor settings. Journal of Environmental Psychology 59, 85-93.

III Pasanen, T., Neuvonen, M., Korpela, K. (2018). The psychology of recent nature visits – (How) are motives and attentional focus related to restorative experiences and changes in mood? Environment & Behavior 50(8), 913-944.

IV Pasanen, T., Johnson, K., Lee, K., Korpela, K. (2018). Can nature walks with psychological tasks improve mood, self-reported restoration, and sustained attention? Results from two experimental field studies. Frontiers in Psychology 9, 2057.

1 INTRODUCTION

More and more studies on human response to the natural world are published every year, and most of them report beneficial effects on mental health or mood (Hartig, Mitchell, de Vries, & Frumkin, 2014; van den Bosch & Ode Sang, 2017). These beneficial responses have been suggested to help to reduce the adverse effects of many global trends on human health, including increased rates of urbanisation, physical inactivity, and the symptoms of mental illnesses. More than half of the world's population live in urban areas, and the proportion is expected to exceed two thirds by 2050 (United Nations, 2018). As more people will reside in smaller areas, the need for places and facilities that promote well-being and stress recovery, potentially parks and forests, is thus growing. Publicly accessible natural environments can also promote physical activity (PA; Kondo, Fluehr, McKeon, & Branas, 2018). Declining rates of PA are one of the leading risk factors for chronic diseases such as cardiovascular diseases and diabetes worldwide (World Health Organization, 2018). Regular PA is, moreover, known to be beneficial for mental health (Fox, 1999; Penedo & Dahn, 2005). Estimates show that the global burden of mental illnesses is comparable to the burden of chronic diseases and that their prevention is therefore equally important (Vigo, Thornicroft, & Atun, 2016). All these issues are global, complex, and multifaceted. This thesis contributes to these discussions by examining interlinkages between human health and well-being, PA, and contact with natural and built environments from the psychological perspective.

The thesis consists of four individual studies that assess person-environment interaction. The overall topic – contact with natural environments and well-being – can be classified within the broad range of people-environment studies. Similar topics are generally studied in a variety of scientific fields such as human geography, architecture and urban planning, cognitive psychology, sports sciences, recreation/leisure studies, positive psychology, environmental epidemiology, and environmental psychology, the field of this thesis. In particular, this thesis relies on the theories and traditions of a subfield of environmental psychology called restorative environments (Collado, Staats, Corraliza, & Hartig, 2017; https://iaps-association.org/ren/). Despite being a subfield of psychology, applied research in

restorative environments has largely focused on physical environmental qualities conducive to restoration, frequently ignoring the role of individual differences (Markevych et al., 2017; Ratcliffe & Korpela, 2018). This thesis contributes to this discussion by analysing self-reported, everyday nature-related activities, their relationship to several well-being measures, and psychological mechanisms behind this relationship.

Besides accumulation of evidence in the research field, the outcomes of this research have potential implications for individuals, health services, and urban planning. Spending time in natural settings is already offered as a form of intervention for patients (so-called nature-based therapies) but it may also serve the general public by providing a cost-effective, preventative tool for stress- and self-regulation (for example, Stigsdotter et al., 2010; Bowler, Buyung-Ali, Knight, & Pullin, 2010a; Irvine, Warber, Devine-Wright, & Gaston, 2013). Natural environments in Finland are abundant and their usage and availability may therefore help to balance out health-related inequality between people of different socio-economic backgrounds (Mitchell & Popham, 2008). However, with increasing rates of urbanisation, the opportunities to access natural environments may become limited. While it may be important to maintain good access to natural environments, we also need to investigate in more detail the benefits that indoor or built outdoor environments can provide (Hug, Hartig, Hansmann, Seeland & Hornung, 2009; Karmanov & Hamel, 2008; San Juan, Subiza-Pérez, & Vozmediano, 2017).

The remainder of this introduction starts by outlining the key concepts, definitions, and the general framing of this thesis (Section 1.1). After that, in Section 1.2., I will introduce the three main mechanisms identified to explain why visits to natural environments and well-being are potentially related. Section 1.3 summarises key results from applied research on the topic examined in this thesis: everyday nature visits and their associations with subjective well-being and restoration, and factors that explain or mediate these relationships. This section also identifies gaps in the current state-of-evidence. Finally, in Section 1.4, I will outline the scopes, aims, and interrelationships of the individual studies that form this thesis.

1.1 Key concepts and framing of the study

1.1.1 Natural environments

The definition of what constitutes 'nature' or 'natural environment' is subjective (Hartig et al., 2014). Usually 'natural' refers to a combination of living greenery such as plants and trees, water elements such as lakes and seas, and non-living organic features such as rocks and cliffs that are of nonhuman origin (Hartig et al., 2014). However, the 'natural' or recreational environments that people perceive as 'nature' often include both natural and artificial or man-made features. For example, while urban parks or recreational forests are usually dominated by vegetation and water elements, such as trees, plants, flowers, lakes, and ponds, they often feature built elements such as cleared pathways and benches, which require human management and maintenance. Thus most places are difficult to strictly classify into either natural or built/urban. Social and individual norms also affect our judgement of what constitutes a natural environment (Hartig et al., 2014).

To overcome the complexity of what is understood by 'nature', researchers in people-environment/restorative environments studies often use terms such as 'greenspace' and 'bluespace' instead, referring to settings that are mainly covered by vegetation or contain some aquatic elements (for instance, van den Bosch & Ode Sang, 2017). Such settings are seen as different from 'urban' or 'built' settings, although some of them, such as urban parks, are often situated in urban areas (and are, accordingly, often referred to as 'urban green'). However, such dichotomies have been criticised for oversimplification and failure to take account of qualitative aspects that are relevant to the usage and perceptions of a setting, such as facilities and aesthetics (M. van den Berg et al., 2015). Furthermore, greenspace and bluespace as concepts ignore visual variation due to season, or they assume that seasonal variation is modest (for instance that the grass is green all year round). In Finland the four seasons have distinct differences that reflect on the primary colours of the natural landscape including both flora and fauna, covering various shades of white, grey, yellow/red/brown, blue, and, of course, green. Thus, the terms greenspace and bluespace do not suffice to describe Finnish natural outdoor environments for most of the year.

Natural spaces in Finland are vast. Most of the land area, 86 per cent, consists of forests (the majority of which is in economic use; Natural Resources Institute Finland, 2018) and nine per cent consists of various freshwater areas, mainly lakes

(Statistics Finland, 2019). In addition, the mainland of Finland has a coastline of 1,250km, 187,000 islands, 168,000 lakes and many other waterways (Statistics Finland, 2019). These natural areas are also easily accessible: statistics from 2010 estimate that the mean distance to the nearest forest is 700 metres, and half of the population lives within 200 metres of a forest (Sievänen & Neuvonen, 2011a). Similarly, the mean distance to a shoreline (usually lake or sea) is two kilometres, while the median is only one kilometre (Sievänen & Neuvonen, 2011a).

In this thesis, the concepts 'nature' and 'natural environments' are used in parallel and they refer to a wide range of green/blue spaces such as urban parks, urban forests, recreational forests, national parks, forests around second homes (usually in the woods), coastal settings, and lake shores. As most of the studies (Studies 1-3) are based on self-reported survey data on everyday experiences, we have relied on the subjective evaluation of the places the respondents have used. The exception is Study 4, a field experiment where the project researchers pre-selected two different types of 'natural' settings for the experiments, a mixed/coniferous forest and an urban park.

1.1.2 Health and well-being

The World Health Organization defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization, 1946). Health has therefore many dimensions, which are all connected to each other. In psychological research, the focus is often on mental health, or mental well-being, focusing on the psychological rather than physiological components of health. More detailed conceptual analysis of mental well-being, mainly due to the emergence of positive psychology, has identified two distinct but closely related aspects of mental well-being: hedonic and eudaimonic (Ryan & Deci, 2001). Hedonic, or, subjective, well-being refers to the subjective experience of positive affective states, such as happiness, and the absence of negative affect or pain (Ryan & Deci, 2001). From the eudaimonic point of view, well-being refers to the experience of meaningfulness and being able to live and act according to one's values (which may not always result in an immediate pleasant state; Ryan & Deci, 2001). Eudaimonic well-being is also referred to as psychological well-being (Linley, Maltby, Woord, Osborne, & Hurling, 2009; Ryff, 2018).

Although the two aspects of well-being are theoretically distinct, they largely overlap empirically (Ryan & Deci, 2001). For example, being able to actualise one's

intrinsic values (that is, the experience of eudaimonic well-being) often enables and makes space for other self-actualised, positively-toned states such as creativity and vitality (an enthusiastic state of having physical and mental energy available to oneself; Ryan & Deci, 2000; Ryan et al., 2010). On the other hand, both creativity and vitality are closely related to affects: creativity is usually preceded by positive affective states (Baas, De Dreau, & Nijstad, 2008), and vitality is often characterised as activated positive affects (Ryan et al., 2010).

In this thesis, the concept of well-being refers primarily to the hedonic view of well-being as most of the measures analysed evaluate affective outcomes, either momentary mood states or longer-term well-being and mental health. In addition, Study 3 assesses creativity and vitality, which have been connected with both hedonic and eudaimonic well-being.

1.1.3 Exposure to natural settings in different types of research designs

In environmental psychology, the definition of exposure to natural settings depends on the type of research conducted. Experimental research traditions, focusing on examining causal mechanisms in controlled settings, are often based on visual exposure such as to photos or window views, or visual/audio exposure that combines videos with sounds. Virtual realities, providing a more immersive setting with option for movement and exploration in a virtual but realistic world, are also becoming more and more common as a means of exposure to natural settings. While these types of laboratory settings have the valuable advantage of controllability, they inevitably lack external validity (Abrahamse, Schultz, & Steg, 2016).

To address the issue of external validity, a vast amount of experimental research investigating contact with natural environments has been conducted outdoors (for example, Barton & Pretty, 2010). The usual procedure is to randomly assign participants to different types of environments and control for exposure time and activity, which typically entails walking or sitting down. Although this kind of exposure resembles everyday life more closely, the settings may not be of the kind that the participants would visit in their own time, and there is more room for external confounders during the study than in laboratory studies (such as passers-by, weather, and animals encountered). Furthermore, when studying human responses to different types of environments experimentally, blinding the participants to the purpose of the study is generally not feasible – people can obviously see where they are taken to. Even if blinding is possible, research ethics recommendations require

that human subjects are informed about the topic and the procedures of the study (National Advisory Board on Research Ethics, 2009). With this information, it is always possible that the individuals who decide to participate have an interest in or a preconception about the topic of the study, which may bias their behaviour or evaluations during the study (for an example, see Haga, Halin, Holmgren & Sörqvist, 2016). The same applies, of course, to many other types of research designs such as survey studies (Davis & Bremner, 2006).

A more 'objective' way of measuring exposure to natural settings is to examine residential environment characteristics, that is, residential exposure, derived from geographical information systems, and/or recorded by the researchers (for example, van Dillen, de Vries, Groenevegen, & Spreeuwenberg, 2012). Although such studies do not suffer from the bias related to using solely self-reported environmental exposure measures, they often lack measures on the types of exposure to natural settings that people experience in their everyday lives. For example, there is often no information on how often the residents visit the natural spaces in their areas and for which purposes (implying active use), or if they have a view over natural scenery from their homes or on the way to work or school (more passive use; Twohig-Bennett & Jones, 2018). Furthermore, the question of which indicators to use to measure residential green- or bluespace exposure depends on the outcomes examined and the data available, and different measures may yield very different results even within a single dataset (for examples, see Klompmaker et al., 2018; Markevych et al., 2017).

Finally, to examine actual, everyday exposure to natural settings, we can examine self-reports of visits to natural settings with survey questionnaires or mobile applications (e.g., Elliott, White, Taylor, & Herbert, 2015; White, Pahl, Wheeler, Depledge, & Fleming, 2017). While the external validity of such studies is far better than that of controlled experiments, they are usually susceptible to known issues using self-report data, such as memory bias and subjective evaluations of what constitutes a natural space (Hine, Kormos, & Marks, 2016). Furthermore, social desirability may be an issue – even though the responses are anonymous, especially when using online surveys instead of face-to-face interviews, it is known that people tend to exaggerate their involvement in many socially and culturally desirable behaviours such as PA (Hine et al., 2016). However, such study settings make it possible to examine actual human-environment interaction in the everyday context.

The studies in this thesis focus on active exposure, that is, visits to natural environments ('nature visits') that examine 'real' outdoor natural environments as opposed to virtual settings. Measures of passive exposure, such as viewing natural

landscapes indoors, are beyond its scope. Studies 1-3 are based on self-reported survey information, focusing on the most recent visit to a natural setting, or comparing PA in different types of settings. Study 4 is a field experiment, where the participants visited a recreational forest or an urban park with the aim of investigating nature visits reminiscent of those in everyday life.

1.1.4 Physical activity

Physical activity refers to 'any bodily movement produced by skeletal muscles that requires energy expenditure' (World Health Organization, 2018). Lack of PA has been highlighted as the fourth most important risk factor for global mortality and as the main cause for several types of cancer, diabetes, and heart diseases (World Health Organization, 2018). Being physically active is also closely connected to mental health (Fox, 1999; Penedo & Dahn, 2005). 'Exercise' is a form of PA that is planned, structured, and purposefully conducted to improve physical fitness. PA as such, however, also comprises household chores, playing, active transportation, recreational activities, and activities conducted at work (World Health Organization, 2018).

The activities in this thesis are broadly referred to as PA throughout the text. With the focus on leisure time, everyday activities that can be conducted in natural settings, the types of PA examined mainly comprise exercise, recreational activities, and active transportation. Thus, physical exertion related to work and household chores are outside the scope of the thesis, with the exception of gardening (in Study 3), which some may consider a household chore.

1.1.5 Correlational approach

The question of cause and effect is important and constantly debated in people-environment studies and psychology (and scientific research in general, for that matter). Experimental research traditions aim to address this issue. In environmental psychology, experimental evidence systematically indicates that exposure to natural settings does, indeed, follow with increases in positive mood states (McMahan & Estes, 2015). Whether it is this mechanism that explains positive correlations between longer-term nature exposure and well-being, however, is another matter. One is tempted to assume that repeated visits to natural settings is conducive to well-being, but it may also be true – at least to some extent – that those who are feeling

emotionally well have more energy and resources to visit natural environments more often.

As randomised controlled trials are difficult to conduct as rigorously as in medical science due to issues of blinding and controllability (Section 1.1.3), longitudinal studies have been seen as one solution to exploring causal associations (Markevych et al., 2017). Such designs, examining the same people repeatedly over a period, have so far been relatively few in people-environment studies (Kondo, Fluehr, et al., 2018). It is also important to bear in mind that longitudinal studies without a random intervention or an experimental component are correlational (Spector, 2019). For example, people do not just randomly move to new areas but choose where to move on the basis of their preferences and financial capabilities. Those who find being close to natural settings beneficial to their well-being, or who prefer to use natural settings frequently for other reasons (for instance, dog owners), may be more likely move to an area where natural spaces are more easily accessible. Finally, some information on causalities can be provided by interventions aimed at either improving the green infrastructure in an area or changing behaviour such as the use of green infrastructure. Intervention studies of this type, however, tend to have issues with their randomisation procedures (Kondo, Fluehr, et al., 2018). Thus the question of cause and effect in the study of well-being and nature visits is difficult to answer and requires more investigation.

In this thesis the focus is on everyday experiences, tendencies, and associations related to nature visits and well-being. Hence, it relies mainly on correlational evidence and does not attempt to assess causal connections.

1.2 Main mechanisms linking visits to nature and well-being

A number of mechanisms explain why visits to natural environments and well-being are connected. Review studies synthesising these mechanisms and proposing frameworks for understanding them have been abundant, often yielding similar results (Abraham, Sommerhalder, & Abel, 2010; Hartig et al., 2014; James, Banay, Hart, & Laden, 2015; Keniger, Gaston, Irvine, & Fuller, 2013; Kuo, 2015). In this thesis I mainly use a recent framework by Markevych et al. (2017), proposed by a large group of experts in people-environment studies. The framework was the outcome of an interdisciplinary workshop that aimed to summarise current state-of-evidence and identify the main knowledge gaps in the study of contact with greenspaces and health. The workshop synthesised three main pathways via which

visiting natural settings and well-being are potentially connected. Although these mechanisms, explained in the following subsections, are distinct from each other, in practice they overlap and are potentially mutually reinforcing (although this is yet to be studied). The focus in the studies in this thesis is mainly on the second and third mechanisms, restoration and capacity building. Yet, the (positive) experiences related to physiological qualities of natural settings (that is, the first mechanism) cannot be disentangled from these, and no such attempts are made.

1.2.1 Reducing physiological harm

Natural settings can provide several physiological benefits in comparison to more built-up outdoor environments or those characterised by heavy traffic (Markevych et al., 2017). An obvious benefit is air quality, with lower air pollutant concentrations in more natural settings (Hirabayashi & Nowak, 2016). Furthermore, the level of noise is often lower in greenspaces and green infrastructure can block or reduce the volumes of unpleasant noise from nearby traffic, for instance (Van Renterghem et al., 2015). Trees and other green elements can also reduce heat in urban areas by providing shade and absorbing solar radiation (Bowler, Buyung-Ali, Knight, & Pullin, 2010b), which in future may be more important in Finland due to global warming. Being outdoors during daylight hours provides people with vitamin D and helps to regulate the circadian rhythm (Beute & de Kort, 2014). Microbacterial exposure is also more diverse in natural settings and may be connected to various health outcomes (Hough, 2014).

It is important to bear in mind that visiting natural outdoor settings may also expose people to negative physiological conditions compared with staying indoors or visiting more urban, built-up settings. For example, being exposed to UV radiation has been recognised as a major cause of skin cancer, and allergic reactions to pollen are more common in greenspaces than indoors (World Health Organization, 2016). Insects such as mosquitoes and ticks may not only cause fear and revulsion in humans (Bixler & Floyd, 1997), but, more crucially, pose them to serious health risks by transmitting vector-borne diseases (World Health Organization, 2016). These adverse effects, however, are outside the scope of this thesis.

1.2.2 Attention restoration and stress reduction

Research in environmental psychology has long recognised that the benefits of visiting natural environments are inadequately covered by physiological harm reduction alone (Hartig et al., 2014). The idea that visits to natural surroundings not only reduce harm but, particularly after stress or mental fatigue, also provide further benefits on attentional, affective, and physiological levels has been referred to as restoration in people-environment studies. The study of restorative environments has been founded on two complementary theories equally relevant to the studies in this thesis.

Attention Restoration Theory (ART) explains the benefits of exposure to natural settings from the cognitive perspective (Kaplan & Kaplan, 1989). The authors make a distinction between directed and involuntary attention. Directed attention is an effort-consuming type of attention that depletes attentional capacities during the day at work or studying, after which arises a need for (attention) restoration. Kaplan and Kaplan (1989) refer to this state as 'mental fatigue'. Mental fatigue results from long periods of having to sustain directed attention, and may exhibit as difficulties in sustaining focus on an attention-demanding task or lapses of attentional focus. Involuntary attention, in turn, refers to an automatic, non-depleting attention that does not require controlled effort. The induction of involuntary attention helps to recover from mental fatigue induced by the excessive use of directed attention. Restorative environments are defined as places that trigger involuntary rather than directed attention and they often contain natural features as opposed to built, man-made elements. A restorative experience, furthermore, usually involves different phases such as clearing the head of cognitive residue, (directed) attention recovery, and life reflection, which the authors state is the 'final' phase of restoration and the most difficult one to achieve. Attention restoration may also potentiate other cognitive benefits such as creativity (via mind-wandering) but research on these is in its infancy (Williams et al., 2018).

In ART, the focus is on the interaction between humans and their surrounding environments and a restorative environment is thought to support at least one of the following four qualities (Kaplan & Kaplan, 1989). Extent refers to the sense of being surrounded by space, experiencing the depth of a place. Compatibility means that the environment can meet an individual's current needs (for example, the level of stimuli needed for recovery may be different between bored and stressed individuals). Being away is a sense of taking distance from everyday issues, possibly distressing ones. Finally, fascination requires that the environment contains features

that capture the individual's attention in an effortless, non-depleting way. Of these, fascination –related to attentional focus– is the most relevant for this thesis.

Another prominent theory in restorative environments research is the Stress Reduction Theory (SRT) by Roger Ulrich (Ulrich, 1983; Ulrich et al., 1991). This theory explains the well-being benefits of exposure to a restorative (natural) environment by means of psychophysiological stress reduction. When exposed to a restorative environment, a stressed individual experiences rapid changes in physiological and affective markers of stress such as blood pressure and level of arousal. After this initial reaction, restoration also spreads to cognitive levels. The SRT acknowledges that individuals may vary in their preferences, and that preferences are closely linked to restorative perceptions. However, humans tend to prefer natural environments as a result of evolutionary development (hence, SRT is sometimes referred to as psychoevolutionary theory). While the evidence on positive affective changes followed by visits to natural settings has been relatively consistent (Barton & Pretty; Bowler et al., 2010a; McMahan & Estes, 2015), meta-analyses and systematic reviews have found both positive and inconclusive evidence for reductions in physiological stress markers (Bowler et al., 2010a; Kondo, Jacoby, & South, 2018; Twohig-Bennett & Jones, 2018).

A large group of experts in environmental psychology have questioned whether ART and SRT have different antecedent conditions (Markevych et al., 2017). Is attentional fatigue substantively different from psychophysiological stress or do they overlap, and if so, to what extent? Kaplan (1995) proposed these ideas more than two decades ago, yet SRT and ART have been considered distinct in applied research on restorative environments. In practice, however, many applied studies, including those forming this thesis, frame their studies with both of these restoration theories.

1.2.3 Building well-being related capacities

Besides providing health and well-being benefits directly, visiting natural environments has been proposed to benefit individuals indirectly by enabling and promoting well-being related activities (Markevych et al., 2017). Such indirect benefits have become known as instoration, or capacity building. The most studied types of capacity building are PA and social cohesion. However, the idea of capacity building may entail other types of personal capacities such as self-confidence and sleep quality (Barton & Pretty, 2010; Kuo, 2015). The common denominator is that although these capacities may be built in various types of environments, natural

settings are often particularly suitable for them and encourage their development. For example, people can be physically active in many kinds of settings but many natural, recreational settings have been specifically designed and actively used for physical activities such as walking.

Natural environments, such as parks near housing, have been proposed to enhance social cohesion by providing a place for not only spending time with one's family and friends but also for meeting neighbours and other people living in the same area, developing social networks and mutual trust (Abraham et al., 2010). Natural spaces can also be a venue for public outdoor events that bring people together. Natural settings further from home, such as national parks, afford opportunities to spend time and interact with family or other intimates without external distractions. Tentative evidence suggests, furthermore, that the quality of interaction may be better in natural settings than in indoor settings (Cameron-Faulkner, Melville, & Gattis, 2018), and that natural settings may buffer the negative effects that lack of social contacts have on well-being (Cartwright, White, & Clitherow, 2018). On the other hand, mentally fatigued or stressed individuals may seek natural environments to escape social pressures (Johansson, Hartig, & Staats, 2011; Staats & Hartig, 2004). In this sense, natural spaces can help to regulate social encounters so that the visit supports current restoration needs.

Natural settings are often suitable or specifically designed for physical activities. For example, urban parks usually contain pathways for walking and jogging, and recreational forests include trails suitable for activities such as walking, running, and skiing. In Finland, natural settings are usually safe and easily accessible throughout the country (Sievänen & Neuvonen, 2011a) and approximately one third of PA during leisure time is conducted in natural outdoor settings (Borodulin, Paronen, & Männistö, 2011). Experimental evidence moreover suggests that conducting PA in natural settings is more beneficial for mood and restoration than PA in built outdoor or indoor settings (Bowler et al., 2010a; Thompson Coon et al., 2011). Yet many questions regarding this finding remain unanswered (Markevych et al., 2017) and the studies in this thesis address some of them, such as whether these results apply to everyday life. Furthermore, natural settings may not only provide a setting for PA but also motivate to be physically active (Shanahan, Franco, Lin, Gaston, & Fuller, 2016).

In the literature, PA in natural settings is often referred to as 'green exercise', broadly defined as 'activity in the presence of nature' (Barton & Pretty, 2010). All the studies in this thesis contribute to the green exercise literature, although I use the

terms 'PA in nature / natural settings' for reasons specified in Sections 1.1.1 and 1.1.4.

1.3 Current state of the evidence and gaps in research

The number of studies assessing the relationship between (natural) environment and well-being has increased dramatically over the past few decades (Hartig et al., 2014). Systematic reviews and meta-analyses have been published more and more frequently. For example, in 2018 alone, at least four synthesis articles on different aspects of human response to contact with nature were published (Houlden, Weich, Porto de Albuquerque, Jarvis, & Rees, 2018; Kondo, Fluehr, et al., 2018, Kondo, Jacoby, & South, 2018; Twohig-Bennett & Jones, 2018). Yet many questions remain unanswered. The focus of this brief summary of the current state of the evidence is on psychological, self-reported well-being outcomes such as general health, mental health, mood, and restoration, instead of physiological stress markers such as blood pressure or diagnosed health conditions. The studies in this thesis address some of these gaps and these are specified in detail in Table 1 at the end of this chapter.

1.3.1 Visual and residential exposure to natural settings and well-being

Studies conducted in the laboratory, mainly assessing visual stimuli, consistently show an increase in positive affect after viewing nature images, compared with urban/built images (McMahan & Estes, 2015). The effect, however, is smaller than in the case of visiting natural settings outdoors (McMahan & Estes, 2015). A recent narrative review criticised the fact that most of experimental laboratory studies have focused on visual exposure and ignored other senses, which may also be relevant for experiencing the psychological benefits of nature exposure (Franco, Shanahan, & Fuller, 2017). Yet tentative evidence tapping into this issue suggests that visual exposure promotes stress recovery better than auditory exposure, or even the combination of visual and audio exposure (Wooller, Rogerson, Barton, Micklewright, & Gladwell, 2018). Studies outside the laboratory on purely visual nature exposure, in the form of window views from home or office, have been scarce, thus their results provide inadequate evidence for reliable synthesis (Houlden et al., 2018).

Residential exposure to natural spaces is often considered a proxy for either visual exposure or a more active exposure, implying visiting natural settings. In terms of living near green or blue spaces, the evidence is accumulating and overall suggests a positive connection with both general and mental health. Regarding mental health the evidence is stronger. A recent meta-analysis by Twohig-Bennett and Jones (2018) concluded that greenspace exposure – mainly residential – correlates systematically with good self-reported health. A similar conclusion was reached by M. van den Berg et al. (2015), who rated the strength of evidence regarding the amount of greenspace exposure and general health as 'moderate'. As for perceived mental health, the evidence base was evaluated as 'strong' (M. van den Berg et al., 2015). Studies on bluespace exposure have been fewer and their procedures and results have been decidedly inconsistent (Gascon, Zijlema, Vert, White, & Nieuwenhuijsen, 2017). A systematic review on the topic thus concluded that there is inadequate evidence regarding bluespace exposure (mainly residential) and better general health and limited evidence regarding bluespace exposure and better mental health (Gascon et al., 2017). Extending cross-sectional analyses, a few longitudinal studies have assessed changes in residential exposure to greenspace or its qualities over time. These longitudinal studies have tentatively found that living in a greener neighbourhood is connected to better mental health (Alcock, White, Wheeler, & Fleming, 2014) and greater life satisfaction (White, Alcock, Wheeler, & Depledge, 2013) in England; however, other studies suggest that the relationship between changes in greenery and mental health differ with age and gender and possibly the specific qualities of the greenery (Annerstedt et al., 2012; Annerstedt van den Bosch, Östergren, Grahn, Skärbäck, & Währborg, 2015; Astell-Burt, Mitchell, & Hartig, 2014).

The limitation in experimental studies and survey studies focusing on residential exposure is that they contain no information on the actual, everyday use of different settings nearby or farther away and their relative contributions to well-being (Markevych et al. 2017). For example, experimental studies generally suggest a positive response regarding mood to viewing nature (McMahan & Estes, 2015) but the relative relevance of (natural) window views from home and visits to one's own garden or a nearby urban park, in terms of well-being, is still largely unexplored (for one example see Korpela, De Bloom, Sianoja, Pasanen, & Kinnunen, 2017).

1.3.2 Well-being and visits to natural environments in general

Whether the positive connection between residential greenspace and mental health is due to actual visits to the nearby greenspaces for any reason (such as passing through, spending time with other people, or being physically active) or to confounding factors remains unknown. Attempts to investigate this topic are accumulating but their results have been inconsistent. For example, M. van den Berg et al. (2017) explored whether time spent in nearby greenspaces mediates the connection between neighbourhood greenery and mental health in four European cities. Mediation was positive across the whole dataset and in one of the cities involved but not in the other three (M. van den Berg et al., 2017). This result could be due to the effect being small and sensitive to sample size, or to differences in greenspace qualities and patterns of use between the study sites. An Australian study by Sugiyama, Leslie, Giles-Corti, and Owen (2008) found that residents in greener neighbourhoods engaged in more recreational walking and felt stronger social cohesion in their neighbourhood, both of which were connected to better perceived mental health. Overall, however, the studies on visits to natural settings are heterogeneous in terms of quality and results and any consensus on the strength of the effect of nature visits on well-being is yet to be determined (Houlden et al., 2018).

Different types of nature visits may also be related to different aspects of well-being. A survey study in England (White et al., 2017) found that the respondents who had visited a natural setting the day before responding reported greater happiness (hedonic well-being), whereas the frequency of visiting natural settings over longer time periods was connected to greater eudaimonic well-being. When controlling for visiting frequency and whether the respondents had visited a natural setting the day prior to the survey, no relationship between neighbourhood greenery or coastal proximity was found (White et al., 2017). This result suggests that the use of natural spaces nearby is the reason why living near these spaces has shown positive well-being connections.

1.3.3 Physical activity in natural settings

According to the capacity building mechanism, natural settings are often suitable for PA. Being physically active is known to be beneficial to general and mental health and positive affect (for example, Fox, 1999; Penedo & Dahn, 2005; Reed & Buck, 2009). In addition, experimental evidence suggests that the benefits of PA on mood can be enhanced by conducting the activity either outdoors, rather than indoors

(Thompson Coon et al., 2011), or outdoors in a natural setting, rather than in built outdoor settings (Bowler et al., 2010a). Studies confirming these results in everyday life, however, have been few. Mitchell (2013) found that more frequent PA in natural environments, including parks and woods, reduced the risk of poor mental health, whereas PA in built outdoor and indoor settings was connected to positive aspects of well-being. De Vries et al. (2013) made a distinction between 'green PA' (walking, cycling, and gardening) and total amount of PA and assessed both as mediators between neighbourhood greenery and health outcomes. Interestingly, it was green activities but not total amount of PA that was positively connected to both neighbourhood greenery and general and mental health (de Vries et al., 2013).

Experimental evidence comparing different physical activities in natural outdoor with built outdoor or indoor settings has grown since the publication of the two abovementioned systematic reviews. For example, Rogerson, Gladwell, Gallagher, & Barton (2016) found that cycling outdoors (in a campus park) promoted social interaction and directed attention more than did indoor cycling, whereas in contrast to many earlier studies, no differences in mood were found. Similarly, comparing indoor and outdoor running (that is, a high-intensity activity), Turner and Stevinson (2017) found no differences in mood during or after the exercise measured by valence and activation. Byrka and Ryczko (2018) compared salsa dancing in indoor and park settings. Dancing in the park turned out to be more physically vigorous and increased positive affect more than dancing indoors (Byrka & Ryczko, 2018).

Another question is whether and how the unique well-being benefits of PA and contact with nature interact. Theoretically, their combined effect could be either sub-additive (that is, their total effect is smaller than the individual benefits), additive (total effect is equal to the sum of the individual benefits), and synergistic (total effect is greater than the sum of individual benefits; Shanahan, Franco, Lin, Gaston, & Fuller, 2016). To study this, Han (2017) assessed the interaction between two levels of greenery and PA intensity to test a hypothesis that greenery and intensity could potentially provide synergistic benefits (that is, demonstrate a positive interaction). The results showed that differences in visible greenery (64% versus 40%) had a stronger positive effect on mood and attention than differences in activity intensity (with jogging increasing fatigue more than walking) but that they had no interactive effects on any of the reported outcomes (Han, 2017). One explanation for the negative effect of greater intensity could be that during low-intensity activity in natural settings there is more time to freely reflect and take in the restorative benefits than in more intense activity, which may require more directed attention (Han, 2017; Kaplan & Kaplan, 1989). Similarly, in an Australian population-level survey study,

mental health was better in greener neighbourhoods and among those engaging frequently in PA, but there was no evidence for their interaction (Ambrey, 2016).

Despite growing evidence, several gaps remain in what is known about the potential well-being associations of PA in natural settings (Markevych et al., 2017). Firstly, we do not know if single bouts of PA are considered more restorative, in quantity or quality, in natural than in built outdoor or indoor settings in everyday life when people have themselves chosen the activities and their settings. Secondly, whether the effects of regular/repeated PA in different types of settings – natural, built outdoor, or indoor – relate differently to longer-term well-being is not known. Mitchell's (2013) study suggests that regular, long-term PA in built versus natural settings may be related to different aspects of well-being but more evidence is needed to verify this. Thirdly, if PA in natural settings is differently (presumably more strongly) related to well-being, is this because of repeated restorative experiences as restoration theories would suggest? The notion that presumably restorative experiences followed by repeated visits to nature accumulate over time into greater well-being is often implicitly assumed (Hartig et al., 2014) but this assumption has not been properly addressed in applied research (Markevych et al., 2017).

1.3.4 Interaction/engagement with the environment

The dominant restoration theories (ART and SRT) both recognise that the interaction (or, engagement) between a person and the surrounding environment is a key quality in the restoration process (Kaplan & Kaplan, 1989; Ulrich, 1983). Yet applied research has been more focused on assessing physical environmental properties than the qualities of interaction with the environment that promote restoration. Whether it is more important to take distance from everyday stressors or to focus on positive features of the natural environment is unknown (Hartig et al., 2014). Interaction with the environment has a behavioural and cognitive component, referring to the activity itself and attentional focus while conducting it (Han & Wang, 2018). In ART attentional focus is related to fascination, the effortless shift of attention towards restorative features in the environment. Whether restorative experiences are stronger if an individual focuses on the (restorative) natural features more while in nature or engages in an activity necessitating engagement with the surrounding natural environment (such as gardening, climbing trees, and so on) is likewise unknown.

To compare different levels of behavioural engagement with the environment, Han and Wang (2018) assigned participants to three groups that either sat down and viewed ('passive exposure'), walked/jogged/moved around ('active exposure'), or collected natural elements ('interactive exposure') in an urban park in Taiwan. After spending 15 minutes in the park, those who had been active reported the least engagement (using a measure combining sensory, cognitive, and spiritual aspects) with the environment, and those who had been interactive, that is, collecting natural elements such as flowers, reported the most engagement. Those who simply viewed the park did not differ from either of the other two groups. These results suggest that engagement with the environment could be enhanced by making behaviour in natural settings more interactive although interactive exposure may not be more beneficial for engagement than 'passive' exposure. What remains unanswered is the degree to which engagement is beneficial for mood and restoration.

Y. Lin, Tsai, Sullivan, Chang, and Chang (2014) experimentally studied (passive) visual exposure with varying levels of greenery and instructions for attentional focus, which they called 'awareness-levels'. They showed the participants five images of urban streetscapes, for 20 seconds each, either 1) with no greenery (no awareness), 2) with greenery - streetside trees - shown in brief flashes difficult to consciously detect (minimal awareness), 3) with greenery shown the whole exposure time (moderate awareness), and 4) with greenery accompanied by instructions to pay attention to the greenery (high awareness). The results showed an increase in cognitive performance as the level of awareness increased. The effect was similar but less marked in terms of perceived restoration; the only significant between-group difference was between the no awareness (no greenery) and high awareness groups (paying attention to the greenery; Y. Lin et al., 2014). The study suggests that drawing attention on green features in urban scenes can be beneficial for attention and perceived restoration.

To study attention during 'real life' outdoor visits controlling for the type of activity, Duvall (2011, 2013) conducted a two-week intervention focused on walking and psychological engagement with the environment during the walks. The participants were randomly assigned to two walking schemes. In the first scheme, participants planned walking schedules with a professional. In the second scheme, the participants were additionally instructed to conduct their walks with engagement strategies self-selected from a number of options. These strategies aimed at perceiving the environment through another role (such as that of an artist or a magician) or focusing on specific senses (for example, smell or touch) during the walk. The underlying idea was that in spite of being unable to modify the

environments visited, participants' perceptions of them could be changed by active engagement and interaction (Duvall, 2011). After two weeks walking increased equally in both conditions but the group doing the awareness-enhancement tasks showed a greater decrease in perceived feelings of frustration and everyday attention failures than did those conducting no particular tasks. These differences, however, had diminished at two-week follow-up. On the other hand, a measure of positive emotions increased in both groups during the intervention and the results suggested an even greater benefit in the standard condition at follow-up (Duvall, 2011).

Although the idea of fascination in ART (Kaplan & Kaplan, 1989) is defined as automatic, non-effortful type of attentional focus, the abovementioned studies imply that deliberately drawing attention to natural features could enhance some of the associated benefits of both viewing and visiting natural settings (Y. Lin et al., 2014). The topic of attentional focus and other forms of interaction with the environment is still novel and much more evidence, especially in everyday experiences, is needed to understand it.

1.3.5 Moderators – environmental, socio-demographic, and psychological

While overall the positive connection between visits to natural settings and well-being seems well established (Hartig et al., 2014), some of the discrepancies in results could be explained by effect modification on the individual and environmental level. Most studies, for example, either stratify their analyses according to gender or include gender as a covariate, which are recommended approaches (for example, Markevych et al., 2017). Yet the evidence on how gender, or indeed most other potential moderators, may affect responses to natural settings has been inconsistent (M. van den Berg et al., 2015). The same applies to different age groups: in older samples the positive response to natural settings tends to be stronger than in younger samples (McMahan & Estes, 2015) but overall both significant and non-significant findings are common (M. van den Berg et al., 2015) and some studies suggest a non-linear relationship (Astell-Burt et al., 2014). The differences found could also relate to varying patterns of use of natural settings (such as frequency of visiting and types of activities engaged in) that most likely differ between different age groups. In experimental research, the population examined is most commonly educated young adults due to the common practise of recruiting university students as participants. Although the present research does not focus on age-related differences in the use

of natural settings, it targets adult population more broadly by examining mainly working-age respondents and participants.

One potentially societally important effect modifier at population-level is socio-economic status (Twohig-Bennett & Jones, 2018). Evidence from England (Mitchell & Popham, 2008; Ward Thompson & Aspinall, 2011; Wheeler, White, Stahl-Timmins, & Depledge, 2012) shows that on the population level residents in the most deprived areas benefit most from access to natural settings. Similarly, on the individual level those with lower SES seem to systematically benefit more from greenery near their homes than do those with higher SES (M. van den Berg et al., 2015). The rationale behind these results could be that wealthier people are generally not only healthier but also have more opportunities for health-enhancing behaviour, such as PA, regardless of the characteristics of their neighbourhoods. For example, they can afford to join a gym or travel to natural settings by car, whereas those with less (financial) resources are more reliant on freely and locally available settings such as urban parks. The abovementioned epidemiological results suggest that improving the accessibility of natural settings may help to balance out socio-economic disparities. However, other studies report contrasting findings and more research is needed on the topic (Markevych et al., 2017).

Aside from individual characteristics, natural environments are evidently all unique and varied and simply grouping all spaces dominated by green or blue elements into one category has been criticised (for example, Karmanov & Hamel, 2008; San Juan et al., 2017). Despite the established need to examine environmental qualities (for example, M. van den Berg, 2015), a common finding in experimental studies has been that exposure - both passive and active - to different types of greenery provides similar restorative outcomes (for example, Rogerson, Brown, Sandercock, Wooller, & Barton, 2016; A. van den Berg, Jorgensen, & Wilson, 2014). Using a large national dataset, with evidently more power than experimental studies to detect nuanced differences, White, Pahl, Ashbully, Herbert, and Depledge (2013) found that compared with 'rural greenspace', visits to the coast, hills/moors/mountains, woodlands/forests, and beaches were associated with greater perceived restoration and visits to playgrounds/ playing fields were associated with less restoration. There is also systematic variation across different types of natural settings in the durations of visits and activities engaged in and these can be related to energy expenditure and post-visit restoration (Elliott et al., 2015). Furthermore, season obviously affects the environment visually, especially in Finland. Preliminary evidence on the effect of season, however, indicates no systematic differences between autumn and winter (Brooks, Ottley, Arbuthnott, &

Sevigny, 2017), or winter and spring (Bielinis, Omelan, Boiko, & Bielinis, 2018) in the benefits derived from nature exposure. Overall, regarding environmental quality, systematic review by Houlden et al. (2018) found only limited evidence for a connection between different types of nature and mental health; this was mostly due to the discrepancy in the measures used to assess quality.

Individual, relatively stable traits may also play a role in restoration experiences. The stronger the connection felt to the natural world, that is, nature-relatedness, the more people in Finland tend to engage in PA in natural settings regardless of urbanicity or overall PA levels (Pyky et al., 2018). A similar result was found in Australia regarding accessibility: orientation to nature predicted park usage more strongly than nearby park availability (B. Lin, Fuller, Bush, Gaston, & Shanahan, 2014). The research is consistent in its findings on this positive association between nature connectedness and well-being (Nisbet, Zelenski & Murphy, 2011), but the quality of most studies on the topic has been poor and the results should therefore be regarded with caution (Houlden et al., 2018). Recent evidence also suggests that other personality traits, such as the well-known Big Five traits, may moderate the effect of visits to greenspace and well-being (Ambrey & Cartlidge, 2017).

Finally, psychological states varying moment-to-moment or between different days could influence the restorative outcomes of nature visits but little is known about this (Joye & Dewitte, 2018). Most of the experimental studies on restorative environments induce a stressor at the beginning of the experiment to create a need for restoration. This approach, however, precludes any inference as to how exposure to natural settings may affect individuals with different prior conditions and needs. Evidence suggests that people choose different activities and settings for different purposes (Calogiuri & Elliott, 2017; Irvine et al., 2013; Kassavou, French, & Chamberlain, 2015), but the extent to which motives affect restorative or affective outcomes has not been extensively explored (for one example, see Siniscalchi, Kimmel, Couturier, & Murray, 2011).

1.4 The present study – scope and aims

This thesis comprises four quantitative studies that examine visits to natural settings from different perspectives. The focus throughout is on everyday experiences – activities the adult population in Finland engage in their everyday lives and how these are associated with momentary mood states, restoration, and/or subjective well-being. Therapeutic nature experiences or longer-term visits such as overnight

camping were not the primary interest in this thesis, although they are potentially important for well-being (for example, Atchley, Strayer, & Atchley, 2012; Korpela, Stengård, & Jussila, 2016).

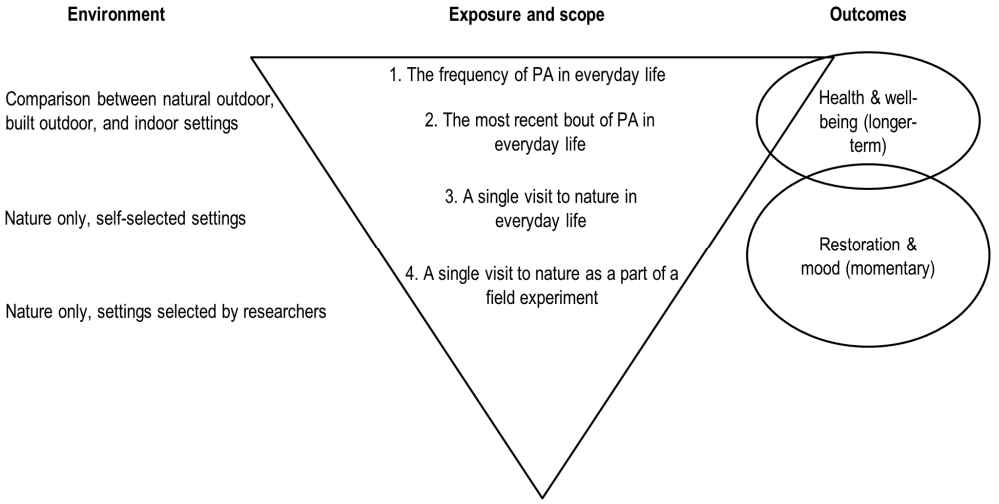

Figure 1. Studies 1–4: Scopes and interrelations

The studies are ordered from one to four according to their scope, starting from more general patterns of PA (Studies 1 and 2), moving on to detailed analysis focusing specifically on nature visits (Studies 3 and 4; Figure 1). Study 1 examines weekly frequencies of PA in indoor, built outdoor, and natural outdoor settings and their relationships with health and well-being outcomes, controlling for a range of individual and situational factors. Study 2 focuses on the most recent bout of PA in everyday life and examines in detail whether restorative experiences and their well-being connections differ in quantity and/or quality in different types of settings (indoor, built outdoor, and natural). Studies 3 and 4 assess individual visits to natural settings using different designs. Study 3 is based on the most recent visit to a familiar place or route in nature in everyday life and the recalled experiences before, during, and after this visit. The emphasis is on assessing how motives and attentional focus explain post-visit outcomes. Study 4, as a result of two field experiments, controls for the settings and the activities but manipulates interaction with the environment. Each study addresses a different gap identified in the literature (see Sections 1.3.3-1.3.5). These gaps are summarised in Table 1, along with brief descriptions of the aims of each study.

Table 1. Aims and gaps addressed in Studies 1-4

Study	Gaps addressed	Section	Aim	Study design
1	We do not know whether repeated PA in nature is more beneficial for well-being than repeated PA in built settings. (Barton & Pretty, 2010; Thompson Coon et al., 2011)	1.3.3	To examine the frequencies of PA in natural and built indoor and outdoor environments and their associations with health and subjective well-being.	Cross-sectional
2	We do not know if restoration is different, in quantity or quality, after a single bout of PA in everyday life in natural and built settings. Factorial validity of the 9-item Restoration Outcome Scale has not been assessed. (Positive) connection between contact with nature and well-being is usually explained by repeated restoration but this has not been properly tested. (Han, 2018; Hartig et al., 2014; Markevych et al., 2017)	1.3.3	To compare restorative experiences (by detailed factor-analytic methods) after a single bout of PA in everyday life in natural and built environments (RQ1), and their connections with longer-term well-being (RQ2).	Cross-sectional
3	Individual psychological factors such as motives and the focus of attention in nature experiences are theoretically relevant but their contributions to restoration and changes in mood have been rarely studied. (Hartig et al., 2014; Y. Lin et al., 2014)	1.3.4, 1.3.5	To explore how motives and attentional focus relate to the outcomes of everyday nature visits.	Cross-sectional
4	The importance of engagement with nature for restoration outcomes has not been properly studied, although it forms a substantial part of ART and SRT. (Duvall, 2011, 2013; Hartig et al., 2014; Kaplan, 2001)	1.3.4	To investigate if psychological tasks focused on interaction with the environment, during a nature walk can enhance affective and attention restoration, compared to a walk without tasks.	Two field experiments (in a forest and an urban park)

2 METHODS

2.1 Datasets and procedures

2.1.1 Studies 1 and 2: Outdoor Recreation Demand Inventory 2010

Studies 1 and 2 are based on the Outdoor Recreation Demand Inventory 2010 (LVVI2), a national survey on outdoor recreation collected by Statistics Finland and the Natural Resources Institute Finland (Sievänen & Neuvonen, 2011b). The survey consisted of eight data collection 'rounds', collected in different seasons, of which two had a specialised section on well-being and restorative experiences related to PA. In these two rounds, the questionnaire was sent to a nationally representative, random sample of 8,000 residents of Finland aged 15-74, of whom 3,060 responded (response rate 38%). To assess any biases in the sample regarding outdoor recreation behaviour, a sample of 301 non-respondents was interviewed by telephone (Virtanen, Nyberg, Salonen, Neuvonen, & Sievänen, 2011). This validity check showed that those who had not responded had similar outdoor recreation patterns to those who had responded and that they had not responded to the survey for various reasons, most commonly lack of time (Virtanen et al., 2011).

2.1.2 Study 3: Follow-up survey

Study 3 is based on a follow-up survey of LVVI2 sent to respondents expressing potential interest in responding to a follow-up survey in autumn 2009. The questionnaire was sent to 869 people, of whom 65% (n = 565) responded. The follow-up questionnaire focused on a typical place or route in nature and the respondents' experiences of their most recent visit there. The respondents did not differ substantially from general population in terms of their outdoor recreation frequency, although women and the more highly educated were overrepresented. The most recent visit to a natural setting was most commonly a familiar route (n =

268), followed by an area (n = 179) and the garden of their home or second home (n = 118) and the activities engaged in were most commonly walking with or without a dog (53%), gardening (12%), and running/jogging (9%).

2.1.3 Study 4: Two field experiments

Study 4 examines two field experiments that were conceptual replications of each other. The first field experiment, hereafter Study 4A, (valid n = 127) took place in a coniferous/mixed forest in Ikaalinen, a small Finnish town, and the second one (Study 4B, n = 119) in a well-maintained, popular urban park near central Tampere, the third largest city in Finland. All participants completed tasks and questionnaires before and after a nature walk on the selected circular routes. They were divided into different experimental groups: a walk with psychological tasks intended to enhance psychophysiological and attention restoration (1/3), a walk with alternative/control tasks (1/3), or a routine walk without tasks (1/3). Brief description of the study design and the participants is provided in Table 2.

Study 4A utilised a circular trail equipped with signposts containing psychological tasks developed on another project (Korpela, Savonen, Anttila, Pasanen, & Ratcliffe, 2017). The main interest in this study was in the order of these 'restoration-enhancement' tasks – they were designed with the idea that restoration evolves in a set sequence, starting with physiological stress reduction and moving on to affective and cognitive restoration (for more details, see Korpela, Savonen, et al., 2017). The tasks at the signposts aimed to address and intensify these restorative phases. The 'alternative' tasks in this experiment were the same tasks but conducted in the reverse order, contrary to theoretical predictions of how a restorative experience evolves. Accordingly, the participants in the 'alternative tasks' condition had to walk the route in the reverse direction. To account for potential differences in the landscape and the route, half of the participants in the 'no task' condition also walked the route in the reverse direction.

For Study 4B the procedure and the restoration-enhancement tasks were updated on the basis of results and lessons learned from the first experiment. Most importantly, the participants were provided with smart phones to navigate with and read the tasks, which enabled everyone to walk the same route in the same direction. Furthermore, using a mobile application ensured better blinding of study conditions and made it possible to test a new battery of alternative tasks. These new alternative

tasks were inspired by Duvall's (2011, 2013) related studies aiming to enhance human-environment interaction but did not address restoration processes as such.

Table 2. Descriptive information of the study settings and the participants in Study 4 (originally published in Pasanen, Johnson, et al., 2018).

	Study 4A	**Study 4B**
Length (km)	6	4
Environment	Coniferous/mixed forest in the countryside	Urban park near the city centre
Where were the tasks read from?	Signposts along the trail	Mobile application
Alternative tasks	Same tasks in the reverse order	Awareness-enhancement tasks (Duvall, 2011)
Design	2 × 2 × 2 (pre-post, tasks/no tasks, route direction)	2 × 3 (pre-post, tasks/no tasks/alternative tasks)
Participants (valid)	150 (127)	122 (119)
Mean age [range]	50 [18-81]	40 [18-63]
Women (%)	80	87

The procedures are outlined in Figure 2. Both studies were carried out in accordance with the recommendations for "Responsible conduct of research and procedures for handling allegations of misconduct in Finland 2012" by the Finnish Advisory Board on Research Integrity (TENK). The protocols were approved by the Ethics Committee of the Tampere Region (Study 4A) and Regional Ethics Committee of the Tampere University Hospital catchment area (Study 4B). All subjects gave written informed consent in accordance with the Declaration of Helsinki. After the study they were debriefed, asked for feedback on the study, and given a single cinema voucher.

All participants completed all measures and tasks reported in this thesis before and after the walk. Both studies contained additional measures that will be reported elsewhere (see Pasanen, Johnson, et al., 2018 for more details). For the nature walk the participants were instructed to walk by themselves and they were given verbal and written instructions one by one. To control for weather and balance the samples in each condition, we assigned participants to three different conditions at each session. The different conditions were internally labelled as A/D (no tasks, D refers to reverse route in Study 4A), B (restoration-enhancement tasks), and C (alternative/control tasks). The participants were systematically assigned to the conditions in this order either according to when they finished the pre-walk tasks (Study 4A) or to their seat in the study premises (Study 4B). For example, if in the first two sessions we had had four participants in each session, they would be

assigned to conditions A, B, C, and A in the first session and to B, C, A, and B in the second.

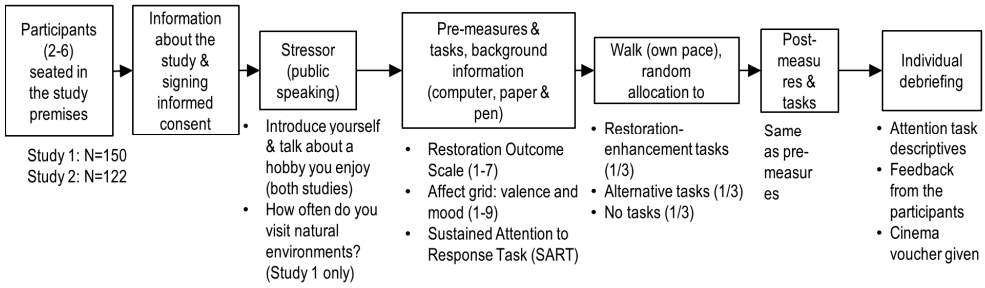

Figure 2. Procedures in Study 4 (originally published in Pasanen, Johnson, Lee, & Korpela, 2018).

For both field experiments, the a priori sample size aimed at was 165, assuming a medium-sized effect (.25) in a 3×2 between-group design with two repeated measures and several correlating dependent variables, with a power of .95 and α = .05 (Gpower 3.1 software; Faul, Erdfelder, Albert-Georg, & Buchner, 2007). However, the samples obtained were smaller due to difficulties with participant recruitment and several cancellations due to bad weather (predicted rainfall, storm, or lightning), most but not all of which could be rescheduled. More details on participant recruitment and invalid cases are provided in the original publication.

2.2 Measures

The next subsections present the main variables of interest in all studies. Additionally, the selection of covariates/confounders varied between the studies. Covariates are listed in Table 3 and the general rationale for their selection is provided in Section 1.3.5. More details on their exact wordings and operationalisations are provided in the original articles.

2.2.1 Well-being, mood and attention – outcomes

Emotional well-being (Studies 1 and 2) in the past four weeks was measured on the Emotional Well-Being subscale in the RAND 36-item health survey 1.0 (Hays, Sherbourne, & Mazel, 1993; Finnish validation by Aalto, Aro, & Teperi, 1999),

comprising five questions (for example, 'Have you been a happy person?'), measured on a 6-point ordinal scale ranging from 'All of the time' (1) to 'Not at all' (6). Three items were reverse-coded so that greater values indicated better well-being. This scale was operationalised as a confirmatory latent factor in the analyses.

In Study 3, one of the outcomes was also labelled as emotional well-being, but instead of an existing, validated scale, it was an exploratory latent factor comprising three items on positive emotions frequently experienced in everyday life (happiness, calmness, and joy; Zelenski & Larsen, 2000), one item on vitality ('I felt alive and vital'; Ryan & Frederick, 1997) and one item on life satisfaction ('I was fairly satisfied with my life').

General health (Study 1) was elicited by a single item (widely used practice, for instance Idler & Benyamini, 1997; Miilunpalo, Vuori, Oja, Pasanen, & Urponen, 1997), 'In general, would you say your health is…', with the options 'good' (1), 'fairly good' (2), 'average' (3), 'fairly poor' (4), and 'poor' (5). This scale was reverse-coded so that greater values indicated better health.

Sleep quality (Study 1) was elicited by a single item 'How often in the past four weeks have you experienced sleep problems or poor sleep quality', options ranging from 'All of the time' (1) to 'Not at all' (6). Asking about sleep problems by a single item has been found to correlate strongly with more comprehensive measures of sleep quality (Carpenter & Andrykowski, 1998). For the analyses, this scale was reverse-coded so that greater values indicated better sleep quality.

Creativity (Study 3) after the most recent visit to a natural setting consisted of four items (such as 'I came up with many new ideas'), evaluated on an ordinal scale ranging from 'Describes my experience completely' (1) to 'Not at all' (7). This scale was developed on the research project (Tyrväinen et al., 2014). These items formed an exploratory latent factor.

Valence and activation (Study 4) were measured with the two-dimensional affect grid in which the participants are asked to evaluate their mood by marking a single cross on a 9 × 9 grid, with the axes representing these two core affects (Russell, Weiss, & Mendelsohn et al., 1989; Västfjäll & Gärling, 2007).

Sustained attention (Study 4) was measured with the Sustained Attention to Respond Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). In SART participants are required to respond to a rapidly-paced stimulus, digits 1-9 on screen, but to withhold their response if the digit is 3. They are asked to pay equal attention to speed and response accuracy. To create the task, we used Stothart's (2015) source code in the open source software PsychoPy (Peirce, 2009). Several measures from this task can be calculated: commission errors that measure response

accuracy, controlled attention, and response inhibition (Johnson et al., 2007; Manly et al., 2003); mean response time (RT); and standard deviation of response time (SDRT) reflecting the stability of responses (Robertson et al., 1997; Manly et al., 2003; Smilek, Carriere & Cheyne, 2010). SDRT was further analysed by differentiating fast and slow frequency attentional lapses (for the methodology, see Johnson et al., 2007), indicating moment-to-moment variability (FFAUS) and slower, gradual changes (SFAUS) in response times. The results for FFAUS and SFAUS were similar to those for SDRT and thus, for the sake of simplicity, they are not discussed in detail in this summary but further information regarding them appears in the original research article.

2.2.2 Self-reported restoration – outcome and mediator

Restoration was measured on the Restoration Outcome Scale (ROS; Korpela et al., 2008). The scale has two versions, a shorter 6-item (ROS6), and a longer 9-item version (ROS9, in which the respondents are asked to what extent different statements describe their experiences. The items may be phrased in the past or the present tense, depending on the design of the study. Drawing from restoration literature (Hartig, Lindblom, & Ovefelt, 1998; Staats, Kieviet, & Hartig, 2003), in the original 6-item version three items measure relaxation and calmness (for example, 'I calmed down'), one attention restoration ('My concentration and alertness increased'), and two clearing one's thoughts (for example, 'I forgot everyday worries'). In the longer version, two of the additional items measure vitality (for example, 'My vitality and energy increased') and one self-confidence ('I became more self-confident'; Korpela & Ylén, 2009; Korpela, 1992; Ryan et al., 2010). All items are evaluated on a 7-point ordinal scale, with greater values indicating greater restoration.

ROS is one of the few measures on self-reported restoration outcomes to include aspects of both ART and SRT (Han, 2018). Like most other restoration measures, its psychometric properties, especially those of the longer version, require more research in different contexts (Han, 2018). In this thesis, ROS is modelled as an exploratory latent factor in Study 2 (mediator, 9-item scale) and Study 3 (outcome, 6-item scale), and as a summary score in Study 4 (outcome, 6-item scale).

2.2.3 Attentional focus during the most recent nature visit – mediator

To examine attentional foci (Study 3) during the most recent visit to a typical place or route in nature, the respondents were asked to what extent they had focused on 'the activity, that is, outdoor recreation' (focus on the activity), 'your own thoughts and emotions' (focus on oneself), 'other people around you' (focus on others), and 'the environment, that is, the natural or urban surroundings' (focus on the environment), on a 7-point ordinal scale ranging from 'completely' to 'not at all' (McIntyre & Roggenbuck, 1998). In the analysis the items were reverse-coded so that higher values indicate greater focus.

2.2.4 The frequency and settings for PA – independent variables

The respondents were asked about the settings in which they had taken their a) most recent bout of PA (Study 2), and b) PA in general (Studies 1 and 2). For the analysis we grouped these into indoor (home or indoor sports facilities such as gyms), built outdoor (such as streets, cycle lanes, sport fields), and natural outdoor settings (for example, nature close to home or to second home, usually a rural summer cottage). Outdoors in front or back yard was excluded because we had no information if these were perceived as built or natural.

Weekly frequencies of PA in indoor, built outdoor, and natural outdoor settings were obtained by multiplying the percentage of PA taking place in each of these settings by weekly frequency of PA overall.

2.2.5 Motives for the most recent nature visit – independent variables

The respondents were asked how important a variety of factors were in their decisions to go outdoors, on a 4-point scale ranging from (1) very important to (4) not important at all (reverse-coded for the analysis; Study 3). These were grouped into motives to be physically active ("maintaining physical fitness"), to socialise ('I can be with friends', 'I can be with family'), to be alone ('I get to be alone'), to reduce stress ('I can relax,' 'I can withdraw from daily routines,' and 'I can reduce stress'), and to experience nature ('I can enjoy nature', 'I can learn from nature'). This categorisation was based on the mechanisms that link visits to nature and well-being (Section 1.2) and Knopf's (1987) categorisation of motives for visiting natural settings.

In the analyses the relationship between these motives and attentional foci (Section 2.2.3; mediators) was specified in two ways based on different theoretical reasoning: Model 1 assumed that motives and attentional focus should theoretically match ('restricted model'), and Model 2 allowed all motives to be connected to all types of attentional foci ('unrestricted model').

2.2.6 Covariates

All studies controlled for different sets of covariates, which were selected a priori in Studies 1 and 2, and in Study 4 post-hoc, based on their association with the outcomes due to smaller sample size.

The analyses in Study 1, assessing everyday PA patterns, controlled for gender, age, household income, household size, exceptional situation in life, constraints for outdoor recreation, season, and general activity level. Studies 2 and 3 did not include any covariates but a sensitivity model reported alongside Study 2 controlled for gender, age, and household income. In Study 4, a number of plausible covariates based on the literature were tested, and those that showed a statistically significant association with an outcome in either study were selected for the analyses. These included stress in the past four weeks, age, start time of the experiment, ease of wayfinding, and method of navigation (mobile application / paper map; Study 4B only). Excluded potential outcomes not related to the outcomes included gender, walk duration, temperature, weather, sleep, and unusual events or fear during the walk (Study 4B only).

2.3 Statistical analyses

All main analyses were conducted with Mplus versions 7-8 (Muthén & Muthén, 1998-2017) and variable calculations and conversions mainly with IBM SPSS versions 23-25. Although technically, the analytical methods used in each study can be called by different names (listed in Table 3), they all belong to the family of methods called Structural Equation Modelling (SEM). SEM usually refers to models using latent variables (in this case, exploratory or confirmatory factors) and/or path modelling (models with observed variables only; Kline, 2016). In this thesis all studies use a combination of observed and latent variables with the exception of Study 4, which uses only observed variables due to its relatively small sample size

(Kline, 2016). Another common feature of the models in this thesis is that they all assess several outcomes simultaneously, thereby making is possible to take account of their intercorrelations.

One of the main advantages of SEM is that, in addition to examining the relationships between variables (that is, local model fit), it provides comprehensive ways to assess the fit between the data and the model as a whole (global model fit), often overlooked in applied quantitative studies (Kline, 2016). It is questionable to interpret a single regression coefficient in a model that does not fit the data well or has some other serious flaws. The criteria for assessing model fit include residual inspection (with correlation residuals < |.10| preferred and z-scores < |1.96| for covariance residuals), a non-significant χ^2-test, and several fit indices based on the χ^2-test such as the Root Mean Square Error of Approximation (RMSEA) < .05/.08, the Comparative Fit Index (CFI) > .90/.95, the Tucker-Lewis Fit Index (TLI) ≥ .90/.95, and the Standardized Root Mean Square Residual (SRMR) ≤ 0.08 (Bentler, 1990; Browne & Cudeck, 1992; Hu & Bentler, 1999; Kline, 2016; Tucker & Lewis, 1973; Yu, 2002). The available means to assess model fit depend on the model and the estimator used. For example, commonly used information criteria (AIC, BIC) are not provided with the diagonally-weighted least squares estimator (WLSMV) applied in some of the studies in this thesis. Although no universal guidelines exist as to what constitutes an acceptable fit, the recommended approach is to comprehensively assess model fit on the basis of various fit indices and the residuals (Kline, 2016). The studies in this thesis generally inspected the model residuals carefully. In problematic cases the models were adjusted to ensure that the results were not due to misspecifications. The reported models were either the original (Study 2) or the adjusted models (Study 4), with the others provided as 'sensitivity analyses'.

Another advantage of using latent factors with observed indicators is the fact that they are able to take into account measurement error prevalent in most variables, especially those using human subjects. Furthermore, the range of available estimators is vast and appropriate options in the studies of this thesis were MLR, suitable for continuous but non-normally distributed variables and WLSMV, suitable for variables measured on an ordinal scale (Muthén & Muthén, 1998-2017).

In interpretation effect sizes are evaluated along with statistical significances. The studies mainly rely on the widely used criterion of p <.05 to indicate 'statistical significance', with the exception of Study 2, where the significance level was set at p <.01 due to multiple testing and the known oversensitivity of the χ^2 test in large sample sizes (Kline, 2016). Because the methods vary slightly between the studies,

different effect sizes are interpreted, including variances explained, standardised and unstandardised regression estimates, mean differences between groups, and estimated change scores between measurements (Kelley & Preacher, 2012; Pek & Flora, 2018). When applicable, effect sizes are evaluated according to the guidelines for social sciences by Ferguson (2009).

Table 3. Statistical methods and variables in Studies 1– 4

Study	Analysis methods	Main explanatory variables	(Mediators)	Outcomes	Covariates
1	Structural regression modelling, with explanatory variables added in four steps	Weekly frequency of PA in indoor, built outdoor, and natural outdoor settings		Emotional well-being, general health, sleep quality	Gender, age, income, household size, exceptional situation in life, constraints for outdoor recreation, season, general activity
2	RQ1: Measurement invariance testing for ROS9 with multi-group exploratory factor analysis RQ2: Multi-group exploratory SEM (ESEM)	RQ2: Weekly frequency of PA in indoor, built outdoor, and natural outdoor settings	RQ2: Restoration of the most recent bout of PA in indoor, built outdoor, or natural outdoor settings	RQ1: Restoration of the most recent bout of PA in indoor, built outdoor, or natural outdoor settings RQ2: Emotional well-being	Sensitivity analysis: gender, age, and income
3	Two ESEM analyses with motives as confirmatory factors and outcomes as exploratory factors	Importance of different motives for the most recent nature visit	Attentional focus during the most recent nature visit	Restoration, creativity, and emotional well-being after the most recent nature visit	
4	Three multi-group regression models (based on study conditions) for blocks of three related outcomes	Conducting 'restoration-enhancement' tasks during a nature walk vs. conducting alternative tasks vs. no tasks		Pre-post -walk changes in restoration, mood, and sustained attention	Stress in the past four weeks, age, start time, ease of wayfinding (both studies), navigation method (Study 4B only)

3 RESULTS

3.1 Study 1 – Direct relationships between PA and well-being

The frequency of conducting PA in natural environments was connected to greater emotional well-being and better general health (Figure 3). Connection to sleep quality was tentatively positive (although weak), but after adding situational covariates into the model this was no longer statistically significant. The frequency of conducting PA in built outdoor environments was also positively connected to general health but not emotional well-being or sleep quality. The frequency of PA indoors, on the other hand, showed no significant connections to the outcomes when taking into account the general level of PA, age, gender, season, household income, exceptional situation in life, having disabilities rendering outdoor PA difficult, and constraints such as stress, lack of time, or facilities inhibiting PA outdoors.

The effects of one additional weekly PA session in nature on emotional well-being (b = .083, s.e. = .03, p = .005) and general health (b = .060, s.e. = .03, p = .039) were slightly greater than the effects of monthly household income increase by a thousand more euros (emotional well-being: b = .048, s.e. = .011, p < .001; general health: b = .024, s.e.=.01, p = .022) but much smaller than the effects of being physically more active in general (emotional well-being: b = .254, s.e. = .043, p < .001; general health: b = .578, s.e. = .043, p < .001). Variances explained in the outcomes ranged from low to moderate: sleep quality 7.9%, general health 26.1%, and emotional well-being 37.6%.

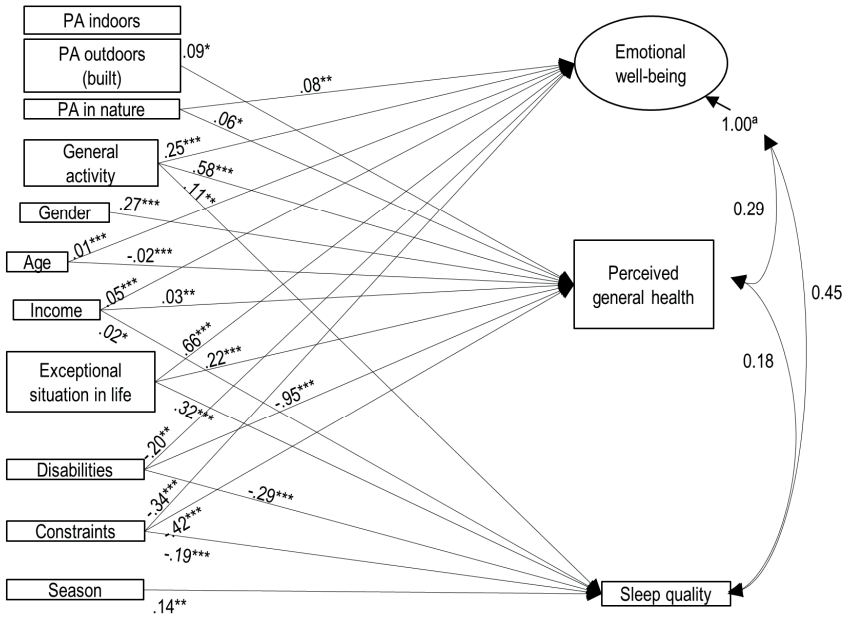

Figure 3. The significant ($p < .05$) paths of the final model in Study 1. $\chi 2 = 518$, df = 59, $p < .0001$, CFI = 0.96, RMSEA = 0.06. The indicators for emotional well-being not shown for clarity. [a]constrained to 1.00 for model identification.

3.2 Study 2 – Recalled restoration and its connections to well-being

The exploratory factor analysis supported a two-factor solution for the ROS9 scale. Factor 1 consisted of the original, 6-item ROS6 scale and was labelled "Restorativeness" (Table 4). Factor 2 consisted of one item on vitality (gaining faith in tomorrow) and self-confidence and was named "Assurance". The second item measuring vitality ("My vitality and energy increased") loaded on both factors equally strongly.

The series of measurement invariance tests suggested that the ROS9 items correlate similarly (that is, they have equal loadings) regardless of the type of environment for PA. However, individual items showed small qualitative differences. Indoor PA was rated highest in terms of gaining self-confidence and forgetting everyday worries and PA in natural surroundings was rated the highest in terms of calmness. When comparing factor means, Restorativeness was rated higher after PA in nature than in built outdoor settings, and the difference from indoor PA

was almost equally large (and significant in the second model). Assurance was equal in all settings.

Table 4. Loadings, item means, and factor means in the best-fitting measurement invariance model in Study 2 (n = 2 535). Means for items a, e, and g were allowed to differ between the groups, all others were constrained to equal. Estimates in bold face: statistically significant (p < .01) difference from the other group(s), or loading >.50. Originally published in Pasanen, Ojala, Tyrväinen, & Korpela, 2018.

	Loadings		Estimated item means		
Item	Factor 1 Restorativeness	Factor 2 Assurance	Indoor	Built outdoor	Nature
a) I calmed down	0.96	-0.03	4.87	5.01[i]	5.12[i], b
b) My concentration and alertness increased	0.94	0.06	4.71		
c) I gained new spirit for my everyday routines	1.04	0.01	4.97		
d) I felt restored and relaxed	1.06	-0.06	5.00		
e) I forgot everyday worries	0.74	0.31	4.94[b, n]	4.70	4.76
f) My thoughts were clarified	0.71	0.40	4.70		
g) I became more self-confident	0.06	1.17	4.54[b,n]	4.35	4.33
h) I gained faith in tomorrow	-0.01	1.30	4.49		
i) My vitality and energy increased	0.54	0.65	4.86		
Factor means (99% CIs)					
Indoors	0*	0*			
Built outdoor	-0.02 [-0.17;0.14]	-0.08 [-0.23;0.07]			
Nature	0.14 [-0.01;0.28]	0.03 [-0.11;0.17]			
Difference (built-nature)	-0.15 [-0.28;-0.03]	-0.11 [-0.23;0.02]			

[n] greater than in 'nature'; [i] greater than 'indoor', [b] greater than 'built outdoor' settings

* reference group; mean constrained to 0

Regardless of the setting, greater Restorativeness was positively connected to emotional well-being (Figure 4). Contrary to expectations, however, Restorativeness did not fully explain the connection between frequency of PA in nature and well-being. Despite taking into account recalled restoration, the frequency of PA in natural surroundings and emotional well-being were positively connected (β = .13, 95% CI [.05; .22]), suggesting that there are other factors that explain the connection between repeated PA in natural surroundings and emotional well-being. This relationship remained positive in a sensitivity analysis taking into account the effects of gender, age, and income on restoration and emotional well-being.

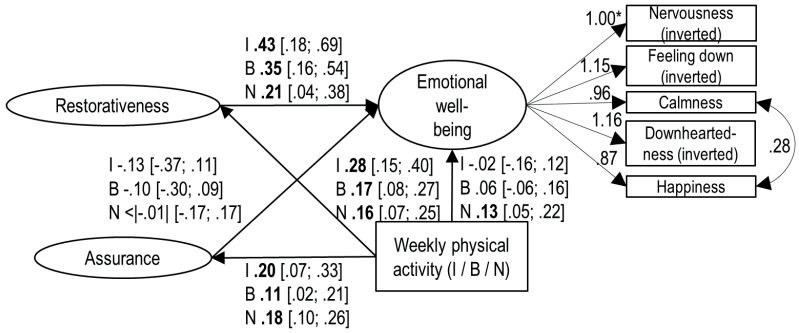

Figure 4. Multi-group exploratory SEM model estimates (standardised with 99% CIs) for the relationships between Emotional well-being, Restorativeness and Assurance, and frequency of physical activity in indoor (I), built outdoor (B) and natural outdoor (N) environments. *N* = 2 568. χ2 = 964.4, df = 291, *p* < .001; RMSEA = 0.05; CFI = 0.96; TLI = 0.96; SRMR = 0.05. Estimates in bold face: *p* < .01. For simplicity, items and loadings of Restorativeness and Assurance not shown. Originally published in Pasanen, Ojala et al., 2018. *constrained to 1.

3.3 Study 3 – Motives and attention in nature visit

The main analysis consisted of two related models: Model 1 restricted the relationship between motives and attentional foci to theoretically match, whereas in Model 2 all motives were allowed to correlate with all types of attentional foci. For example, in Model 1 the 'motive to be physically active' was restricted to correlate only with 'focus on the activity', whereas in Model 2 it was free to correlate with all of the assessed attentional foci.

In both models motives and attentional foci explained moderate shares of variation in recalled restoration (54%–57%), creativity (22%), and emotional well-being (33%–37%). The models fit the data equally well (CFI = .98, RMSEA = .05; Model 1: $\chi^2 = 664$, df = 279, $p < .001$; Model 2: $\chi^2 = 629$, df = 266, $p < .001$). This section summarises the strongest results that were similar in both models.

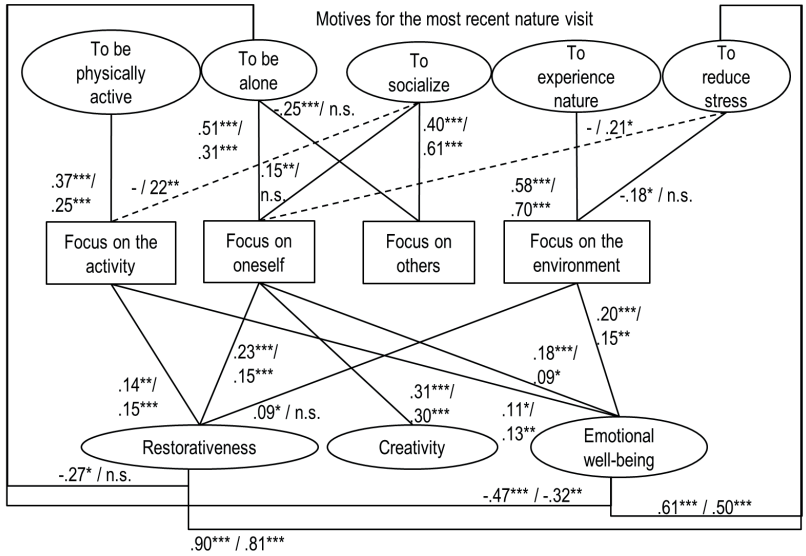

Figure 5. The significant ($p < .05$) standardised estimates in Models 1 and 2, separated by '/' ($n = 565$). Dashed line: path tested only in Model 2. The latent variables are shown in ellipses. For readability, the indicators of the latent variables, covariances, and residual correlations are not shown. Originally published in Pasanen, Neuvonen, & Korpela, 2018. *$p < .05$. **$p < .01$. ***$p < .001$. n.s.= non-significant.

Focusing on the activity, on oneself, and on the environment - but not on other people - were positively connected to at least one of the post-visit outcomes (Figure 5). Of the different foci, focusing on oneself was the only one to be positively connected to all three outcomes in both models, with standardised estimates ranging from .09 to .31. Most of these estimates were just under or slightly above the recommended minimum of .2 for practical significance (Ferguson, 2009).

All motives showed at least one positive indirect relationship with the post-visit outcomes via attentional focus (Table 5). No negative indirect relationships were apparent. Additionally, the motives to reduce stress and to be alone were directly associated with recalled restoration and emotional well-being but the associations were in the opposite directions. When controlling for attentional foci, the stronger the motive to be alone had been, the less restoration and the lower emotional well-being had the respondent reported. The motive to reduce stress, on the contrary, was strongly connected to reporting more restoration and greater emotional well-being. Similar patterns were observed with total effects: motives to be alone and to reduce stress were the only ones to consistently show significant total effects on restoration (motive to reduce stress: .83 – .88) and emotional well-being (motive to

reduce stress: .50 – .57; motive to be alone: -.40 – -.31). In terms of effect sizes the positive total effects from the motive to reduce stress on restoration were moderate (.50 – .57) and on emotional well-being they were strong (.83 – .88). The negative total effects from the motive to be alone on emotional well-being were smaller but well above the recommended minimum for practical significance (-.40 – -.31).

Table 5. Standardised direct, total indirect, and total effects from the motives to the outcomes in Models 1 and 2 (Study 3), separated by '/'

	Restoration			Creativity			Emotional well-being		
Motive to…	Direct	Total indirect	Total	Direct	Total indirect	Total	Direct	Total indirect	Total
Be physically active	-.07 / -.07	.05** / .05**	-.02 / -.03	.00 / .00	-.01 / .01	-.01 / .01	.08 / .05	.04* / .04*	.12 / .10
Be alone	-.27*** / -.13	.13*** / .05	-.15 / -.08	-.11 / -.03	.16*** / .08*	.05 / .05	-.47*** / -.32**	.10*** / .01	-.37** / -.31**
Socialize	-.13 / -.11	.02 / .03	-.12 / -.08	.03 / .07	.05 / -.01	.07 / .06	-.18 / -.16	.01 / .03	-.17 / -.14
Reduce stress	.90*** / .81***	-.02 / .02	.88*** / .83***	.12 / .10	-.01 / .06	.15 / .15	.61*** / .50***	-.04 / -.01	.57*** / .50***
Experience nature	-.13 / -.10	.05 / .03	-.08 / -.07	.15 / .16	.04 / .03	.19* / .19	.04 / .11	.11*** / .09	.16 / .20

*p < .05, **p < .01, ***p < .001

3.4 Study 4 – Psychological tasks during nature walks

In both field experiments, nature walks resulted in more positive mood and enhanced restoration regardless of whether the participants conducted psychological tasks (Figure 6, Figure 7). In terms of attention, the results were mixed. In Study 4A, conducting the restoration-enhancement tasks in the opposite order, ending with physiological relaxation, showed consistent improvement on sustained attention (indicated by an average of 1.5 fewer commission errors, no change in mean RT, and reduced SDRT), whereas the same tasks in the designed order were the least "effective", that is, showing no change in terms of commission errors, mean RT, or SDRT. Both no-task groups showed reductions in the number of commission errors (2.2-2.6 fewer errors) but no changes in mean RT or SDRT. However, the pattern for SDRT was very similar to the reverse-order tasks group but the standard errors were relatively larger (Figure 6). In addition, in terms of mean RT there was a significant interaction between route direction and tasks: in the clockwise route, conducting the tasks, versus conducting no tasks, was associated with increased reaction times, whereas in the reverse route conducting the tasks, versus not

conducting tasks, was associated with reduced reaction times (b = -52.55, s.e. = 25.10, p = .04; Figure 6).

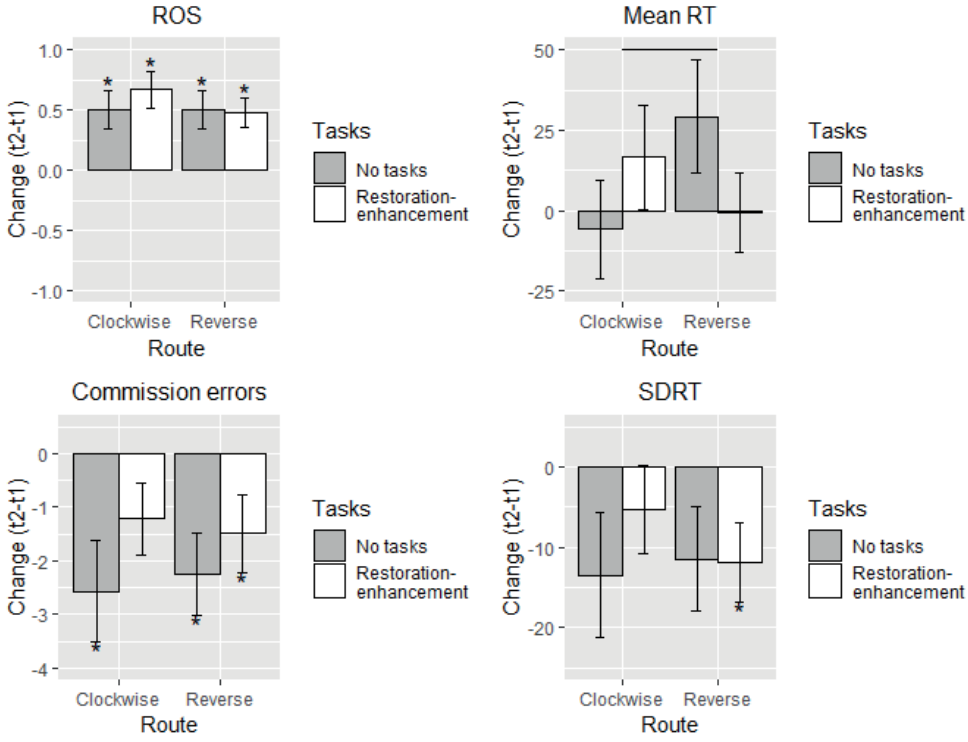

Figure 6. Pre-post walk changes in self-reported restoration (ROS) and commission errors, mean reaction time (RT) and standard deviation of RT (SDRT) in a sustained attention task in Study 4A (n = 125-129), adjusted for covariates. *estimate differs from 0 significantly (p < .05). Solid-line: significant between-group difference.

In Study 4B those who conducted the modified restoration-enhancement tasks made on average 1.6 fewer commission errors (s.e.= .79, p = .05) after the walk but their mean RT and SDRT remained the same (Figure 7). The participants in the no-task group also made fewer commission errors after the walk (b = -1.99, s.e. = .70, p < .01) but their mean RT increased by 29ms (s.e. = 11.53, p =. 02) and SDRT showed no changes. The awareness-enhancement tasks group showed no changes in any of the SART measures assessed.

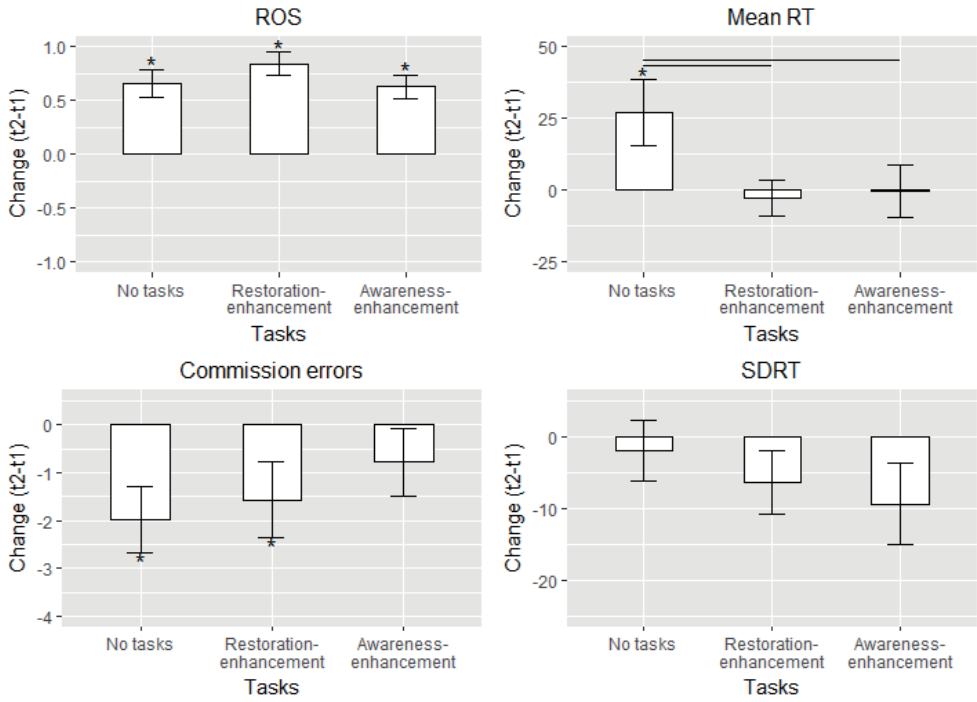

Figure 7. Pre-post walk changes in self-reported restoration (ROS) and commission errors, mean reaction time (RT) and standard deviation of RT (SDRT) in a sustained attention task in Study 4B (n = 116-118), adjusted for covariates. *estimate differs from 0 significantly (p < .05). Solid-line: significant between-group difference.

Concerning the covariates, in Study 4A reporting problems with wayfinding was consistently related to experiencing less restoration, less positive mood, and more problems with sustaining attention (indicated by more commission errors and faster mean RT) after the walk (Table 6). Those who had been more stressed in the past four weeks reported greater positive change in restoration. Age or start time of the experiment were not connected to changes in these outcomes.

In Study 4B, navigating with a paper map rather than a smart phone was associated with more commission errors and, in one group, with reduced mean RT (Table 6). Reporting more stress in the past four weeks was associated with making fewer commission errors (in one of the groups) and reduced mean RT. Those who started the experiment later, usually after work, made more commission errors in the attention task, combined with reduced mean RT and SDRT in some of the experimental groups. Age or experiencing issues with wayfinding were not associated with changes in any of the outcomes.

Table 6. Estimates (s.e.'s) of the covariates in Studies 4A and 4B, separated by "/" if differed between the grouping factors in the multigroup models (Study 4A: clockwise / reverse route direction, Study 4B: no tasks / restoration-enhancement tasks / awareness-enhancement tasks).

	Restoration		Commission errors		Mean RT		SDRT	
Study	4A	4B	4A	4B	4A	4B	4A	4B
Stress	.24* (.11)	.16 (.11)	-.92 (.64)	-1.75* / 2.51 / .49 (.77 / 1.38 / .77)	30.06 / -5.20 (19.56 / 12.44)	-16.03* (7.83)	-5.20 (4.79)	-8.73 (4.48)
Start time	.03 (.11)	-.16 (.17)	-.40 (.47)	2.74** (.85)	9.17 (10.28)	-61.86*** / -33.67* / -14.47 (12.81 / 14.33 / 13.25)	-2.91 (3.87)	-24.01** / -1.61 / .94 (7.62 / 5.97 / 12.31)
Age	-.01 (.00)	.00 (.01)	-.02 (.02)	-.01 (.04)	.23 (.44)	-.43 / .79 / -.97 (.69 / .53 / .61)	-.19 (.19)	-.38 / .36 / -.28 (.36 / .31 / .36)
Wayfinding problems[a]	-.70** (.23)	.02 (.11)	2.91** (.98)	-.67 (.72)	-57.44* (22.73)	9.93 (6.95)	-15.15 (8.60)	4.50 (3.70)
Navigation method[b]	na	.12 / -.27 / -.24 (.14 / .15 / .12)	na	1.30** (.48)	na	4.83 / -25.36** / 5.96 (7.83 / 8.99 / 8.68)	na	-3.16 (2.95)
R^2	.20/.21	.41/.12/.11	.88/.88	.23/.91/.13	.12/.13	.20/.16/.06	.05/.07	.24/.07/.04

[a] Study 4B: Ease of wayfinding, ordinal 1-4 scale
[b] Ordinal scale: smart phone / both / paper map
na = not applicable

*p < .05, ** p < .01, ***p < .001

4 DISCUSSION

This thesis assessed PA in natural surroundings in comparison to other settings and its relationship with well-being outcomes, and nature visits in greater detail. The main contribution of the studies was that they focused on everyday perspectives and behaviour, thereby complementing controlled experiments that lack external validity and epidemiological studies based on registry data but lacking information on everyday behaviours. Although the main results concur with the majority of earlier studies (Sections 4.2.1–4.2.3), the studies in this thesis also raised new aspects that may be important to consider in prospective scientific studies on restorative environments (Section 4.5).

4.1 Summary of the main findings

The main findings of the thesis are summarised in Figure 8. Study 1 found that more frequent PA in natural settings was connected to better emotional well-being and better general health, even when controlling for general activity level and for situational and socio-demographic factors. More frequent PA in built outdoor settings was likewise connected to better general health but not to emotional well-being. Frequency of indoor PA showed no connections to any of these outcomes.

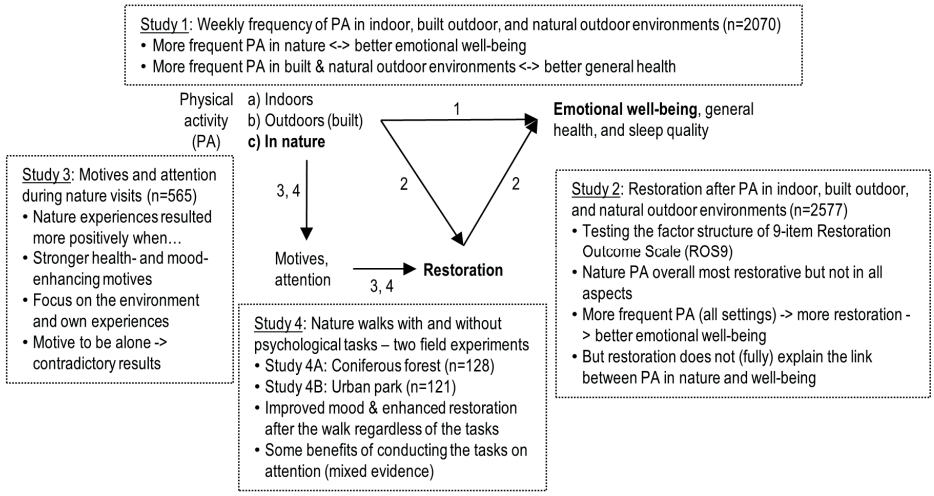

Figure 8. Summary of the main results of Studies 1–4

Study 2 found that the positive relationship between the weekly frequency of PA in natural settings and emotional well-being established in Study 1 was not explained by recalled restoration from the most recent bout of PA. The study assessed restoration outcomes in detail with ROS9, which was evaluated after a single bout of PA, and found 1) that the items formed two strongly correlated latent factors, named Restorativeness and Assurance and 2) that Restorativeness, but not Assurance, tends to be slightly greater overall after PA in natural compared with indoor or built outdoor settings, although not in all aspects.

In Study 3 recalled motives before and attentional focus during the most recent visit to a familiar place or route in natural surroundings explained substantial shares of post-visit restoration and emotional well-being. Of the various motives assessed, stress reduction was by far the most strongly connected to greater post-visit restoration and emotional well-being and it was not related to attentional focus. Motive to be alone, on the other hand, showed a moderate negative direct connection but a (weaker) positive indirect connection to emotional well-being via focus on one's own thoughts and emotions. Placing more focus on oneself, on the activity, and on the surrounding environment, but not on other people, were related to more restoration and emotional well-being. Focus on oneself was the only type of attentional focus assessed that was significantly connected to greater post-visit creativity.

Study 4, summarising two field experiments, found that walking 4–6 kilometres in natural settings resulted in greater restoration and more positive mood regardless of whether tasks were conducted during the walk or not. However, there were some differences in changes in sustained attention and these were mostly between the different types of tasks during the walk. Conducting two different versions of theory-driven 'restoration-enhancement' tasks resulted in improved sustained attention, whereas conducting either the original version of these tasks, starting with relaxation and ending with reflection, or 'awareness-enhancement' tasks (inspired by Duvall, 2011 & 2013) was not connected to any changes in sustained attention. The role of stress before and during the walk emerged as relevant: those who had been more stressed in the past four weeks showed greater positive changes in both studies, whereas stress during the walk, indicated by issues with either wayfinding or the devices used for wayfinding, was associated with less restoration and more impulsive response style in the sustained attention task.

4.2 Findings in relation to recent evidence

4.2.1 Subjective well-being and everyday nature visits

The result showing that emotional well-being is positively associated with repeated PA in natural settings – but not in indoor or built outdoor settings – are in line with those of experimental studies, which have systematically reported evidence for short-term mood enhancement following PA in outdoor versus indoor settings (Thompson Coon et al., 2011) and natural outdoor versus built indoor or outdoor settings (Bowler et al., 2010a). Similar to the population-level analysis by de Vries et al. (2013), repeated PA in any outdoor settings, natural or built, was connected to better general health. De Vries et al. (2013) also found a positive connection between 'green activities' and mental health but they did not distinguish between activities in natural and built outdoor settings and, thus, these results are not entirely comparable. On a more general level, this result corroborates Mitchell's results (2013) showing that PA in natural outdoor settings is connected to better mental health. However, Mitchell (2013) used a more refined categorisation of the settings for PA, and found these connections specific to PA in woods/forests and open spaces/parks. On the other hand, a measure of positive aspects of mental health was connected to PA in

built indoor ('gyms/sports centres') and outdoor ('sports pitch/outdoor courts') settings (Mitchell, 2013), partially contrasting with the findings in this thesis.

Research traditions on restorative environments tend to justify and explain all positive connections between subjective well-being and visits to natural settings by their restorative qualities and the associated restoration theories. In the present research, this implicit assumption that longer-term well-being outcomes of contact with nature are due to repeated restorative experiences was not supported. Even though recalled restoration was connected to PA frequency (in line with e.g., Hug et al., 2009), it did not mediate the connection from frequency of PA in nature to emotional well-being. This result suggests that the positive connection between frequency of PA in natural surroundings and emotional well-being could be due to factors other than restoration, such as duration of the visit (White, Pahl, et al., 2013), personal orientation towards natural environments (Morton, van der Bles, & Haslam, 2017), environmental qualities that promote well-being such as facilities for PA (M. van den Berg et al., 2015), and other positive responses to nature apart from restoration (Richardson, McEwan, Maratos, & Sheffield, 2016).

4.2.2 Restoration and its predictors in everyday nature visits

Addressing the call to examine the different types of needs that PA in built and natural, indoor and outdoor settings may serve (Mitchell, 2013), the present research found that recalled restoration after a single bout of PA in everyday life was greatest when conducted in natural rather than indoor or built outdoor settings, when using a traditional self-reported measure of restoration (namely, ROS6). This result is in line with the vast majority of experimental research in environmental psychology highlighting the restorative qualities of natural settings (e.g. Hartig et al., 2014). It also suggests that the results from experimental studies are not solely due to biases in experimental designs such as selecting unpleasant built comparison settings (Karmanov & Hamel, 2008; San Juan et al., 2017) but that their results may apply to everyday life. However, the differences in the perceived qualities of restorativeness were not entirely consistent between the different types of settings. A measure based on more novel evidence, labelled 'assurance', was experienced equally strongly in the different types of settings, and items on self-confidence and forgetting everyday worries were even rated highest after PA in indoor settings. These differences could be due to the fact that in everyday life the activities performed in different types of settings inevitably vary. For example, any progress and associated increases in self-

esteem may be easier to monitor and detect when lifting weights in the gym than when walking in the forest. Furthermore, indoor settings can provide a wider variety of activities and are less susceptible to changes in season, weather and daylight than PA outdoors. This aspect cannot be fully taken into account in experimental research designs which have usually focused on physical activities that are popular outdoors but not indoors, such as walking, cycling, and running (Husu et al., 2011). New efforts have been made to expand the variety activities in restoration assessments, including activities such as salsa dancing (Byrka & Ryczko, 2018) and similar efforts are called for in the future.

When focusing solely on visits to natural environments, self-reported restoration consistently increased in the studies of this thesis, which is in line with the majority of experimental research on restorative environments (Barton & Pretty, 2010; McMahan & Estes, 2015). Furthermore, supporting many earlier studies (Brooks et al., 2017; Bielinis et al., 2018; McMahan & Estes, 2015; Rogerson, Brown, et al., 2016; A. van den Berg et al., 2014), the changes in self-reported restoration were not associated with the type of environment (a maintained urban park or a coniferous/mixed forest), gender, weather, temperature, or visit duration. As for attention restoration, measured by SART, a task on sustained attention, the results were more nuanced than in the case of self-reported restoration outcomes (consistent with Y. Lin et al., 2014). On a general level, however, sustained attention improved in terms of commission errors followed by a 4-6 kilometre nature walk (cf. Ohly et al., 2016; Stevenson et al., 2018), which suggests less mindlessness and fewer attentional slip-ups also in everyday life (Robertson et al., 1997).

Stress prior to the nature visit was among the strongest predictors of restoration outcomes: those who reported more stress or specified a need to reduce stress experienced greater self-reported and sustained attention restoration (similar to Siniscalchi et al., 2011 regarding the motive to reduce stress). These results are unsurprising given that individuals with higher initial levels of stress have a greater potential for restoration and recovery and they may use visits to natural settings as a means of self-regulation (Hartig et al., 2014; Korpela & Ylén, 2009; Korpela et al., 2018). They are also in line with SRT, which emphasises the stress-alleviating qualities of natural environments and stress as an antecedent condition required to experience restoration (Ulrich, 1983). Accordingly, earlier empirical studies also indicate that stressed individuals are more inclined than non-stressed individuals to visit natural environments (A. van den Berg, Hartig & Staats, 2007), and that the purpose of these visits is usually relaxation and stress reduction (Stigsdotter & Grahn, 2011). It was also unsurprising that stress during the nature visit had a

negative effect on self-reported and sustained attention restoration in the field studies of this thesis (in line with Bixler & Floyd, 1997; Gatersleben & Andrews, 2013; Staats & Hartig, 2004). Although stress during these nature walks was by no means not intended, some participants perceived wayfinding or having to focus on wayfinding on a new route stressful and this was clearly reflected in their post-visit responses in a negative way.

4.2.3 Restoration and interaction with the environment during nature visits

Attentional focus and interaction with the environment were examined in this thesis in relation to restoration outcomes in two ways. The first was a correlational approach, where respondents were asked to recall what they had focused on during their most recent visit to a natural setting. The second was an experiment in the field where some participants were assigned so-called restoration-enhancement tasks, aimed at inducing restoration via engagement with the environment, during a nature walk. Overall the results showed that there are many different types of attentional focus that can be associated with positive restoration outcomes, and placing focus on the surrounding environment, which is potentially related to the concept of fascination in ART (Kaplan & Kaplan, 1989), is only one of them. This idea corroborates Duvall's (2011) results showing that person-environment interaction does not need to be of a specific kind but that potentially many kinds of interactions can enhance self-reported restoration.

The fact that focusing on the environment during an everyday nature visit was associated with enhanced self-reported restoration, nevertheless, suggests that positive outcomes followed by nature visits can be due to positive engagement and interaction with the environment, not only absence of stressors (Hartig et al., 2014). However, it was particularly interesting that of the various attentional foci, focusing on one's own thoughts and emotions during a nature visit was most strongly connected to self-reported restoration. This result implies that this focus was a constructive cognitive reappraisal or deeper life reflection rather than rumination, as indicated by many earlier studies (Bratman, Hamilton, Hahn, Daily, & Gross, 2015; Gross & John, 2003; Herzog, Black, Fountaine, & Knotts, 1997; Kaplan & Kaplan, 1989). In this regard, the results of the field experiments were partially inconsistent with those of the survey study: the restoration-enhancement tasks had content related to focusing on oneself and on the environment but conducting them did not enhance (or for that matter reduce) self-reported restoration after a nature walk in

comparison to not conducting them. However, as we did not measure the focus of attention during the nature walk, we do not know to what extent the tasks actually succeeded in enhancing and addressing person-environment interaction; this is an interesting area to investigate in the future.

The ART relies on fascination as a key component in the restorative process. Considering that the present research found that recalled focus on or instructed engagement with the environment was not necessary for experiencing post-visit restoration, a relevant follow-up question is whether these measures or conditions can be considered fascination, as defined by the ART. The ART sees fascination as an involuntary, non-depleting type of attentional focus (Kaplan & Kaplan, 1989), but whether it is also conscious, that is, whether one is able to recall it, is not known. Y. Lin et al. (2014) found experimental evidence that both unconscious visual exposure to and directed focus on greenery in streetscape images can enhance attention restoration. Duvall's (2011) intervention likewise indicated that consciously directed attention on the environment could enhance self-reported restoration. Whether this type of conscious interaction and engagement with the environment is conceptually the same as fascination, which lacks clear operationalisation (Joey & Dewitt, 2018), or another aspect of person-environment interaction remains a question for prospective studies to assess.

Although in the field experiments self-reported restoration outcomes were very similar regardless of instructed engagement with the environment, sustained attention restoration was more sensitive to the experimental conditions (in line with Y. Lin et al., 2014). Conducting restoration-enhancement tasks ending with relaxation was associated with better sustained attention, whereas conducting either the same tasks ending with reflection or so-called awareness-enhancement tasks was associated with no changes in sustained attention after the nature walk, compared to before. The finding that the contents of the tasks and their order, favouring tasks addressing different phases of restoration and ending with relaxation, were relevant in terms of sustained attention emphasises the complexity of person-environment interaction (Kaplan & Kaplan, 1989). Replications and more detailed investigations are needed to reliably explain the differences between different types of tasks.

4.3 Limitations

As always, the studies in this thesis include several limitations. Firstly, all studies rely mainly on self-reported measures that are prone to different types of biases. One

such limitation is social desirability; people may, explicitly or implicitly, reply in a way that they know is socially expected of them. This is especially an issue with estimations of PA behaviour, which are generally greater than objectively measured levels of PA (Hagstromer, Ainsworth, Oja, & Sjostrom, 2010). However, exaggerations are usually similar in different demographic groups (Hagstromer et al., 2010) and probably regarding PA in different types of settings. Individual variations in response styles may also cause some bias – some tend to use the extremes of the scales more than others. This issue could be better controlled in a repeated measures design, where responses are modelled on a within-level, that is, relative to the respondents' own responses to the same measure/question.

Another major limitation is related to survey research as a research design. When asked about events or habits in the recent past, typically in the past four weeks, the responses are prone to memory bias (Cooper, 1998). An alternative to this would be to use diary recordings or other experience sampling methods to ask questions during nature visits. Such designs might produce more objective records (Wirtz, Kruger, Napa Scollon, & Diener, 2003), although the visits and experiences might lack authenticity due to the awareness of being recorded (Stewart & Hull, 1996). Another issue is how diary data recording might influence the subjects' behaviour, perception of different activities, and mood and thoughts. Participation in this type of study may serve as an intervention as such (the Hawthorne effect; Fife-Schaw, 2006). Another issue in these designs is missing data and drop-outs, which are not easy to handle (Pedersen et al., 2017).

As mentioned in Section 1.1.5, the cross-sectional data used as the basis for Studies 1-3 is not suitable for the assessment of causalities. This is a well-known bias and difficult to overcome with topics that cannot be completely designed as double-blind controlled clinical trials. Cross-sectional data does have value in describing behaviours, tendencies and patterns but these should not be falsely interpreted as causalities that can directly address questions such as how to enhance PA or well-being on the population level. Well-designed interventions or quasi-experimental designs with appropriate comparison conditions are needed to address the issue of whether, and to what extent, improving access or usage of public natural outdoor areas can enhance health and well-being on a larger scale (Markevych et al., 2017).

Declining response rates is a limitation that applies to most research on human subjects where participation is voluntary because it questions the core assumptions of representativeness and randomness of the sample (Sturgis, 2006). This issue applies to all the studies in this thesis. The outdoor recreation data used for Studies 1 and 2 addressed the issue best by conducting a non-respondent survey by

telephone (Virtanen et al., 2011). Importantly, the results showed no systematic differences in the outdoor recreation patterns of those who responded and those who did not although in the sample itself women and older age groups were slightly overrepresented relative to men and younger age groups. In Study 3 the gender bias was more marked (60.2% women) but weekly outdoor recreation frequency was similar to that in the main survey. However, it is likely that the sample consisted of people with a particular interest in outdoor recreation: they had already responded to a long questionnaire on the topic, agreed to take part in a follow-up survey, and responded to the second survey that was also relatively long and detailed with 22 pages of questions. In Study 4 the samples were too small (n = 129/122) to be representative to begin with, which is a default in experimental research; nevertheless, women were decidedly overrepresented relative to other genders (80% in Study 4A and 87% in Study 4B). The fact that we deliberately recruited a non-student sample was an advantage in the sense that the study could provide new information on restoration for different demographic groups. Most experimental research assessing contact with nature and mood has relied on university student samples that consist of relatively young and healthy populations. For example, in the meta-analysis by McMahan and Estes (2015), the oldest mean age in the sample was 28.5 years. On the other hand, with more diverse samples there may have been more variation in the procedures due to having participants unused to psychological measures and experiments.

Although all studies were focused on being active in different settings, the type of activity or its intensity (physical strain) was not controlled for. In Studies 1 and 2 the PA frequency measure was restricted to bouts of at least 20 minutes' duration but there were no additional questions on the durations of single bouts (the most recent PA; Study 2) or the PA sessions in the different settings (Study 1). In the study by Korpela et al. (2014), based on the same data but restricted to natural settings, PA duration correlated positively but weakly with restoration (r = .14, p <. 01) and emotional well-being (r = .05, p < .05). Whether these correlations are similar in indoor or built outdoor settings could not be assessed because they were not asked about in terms of indoor or built outdoor PA. In Study 3, the duration of the most recent visit to a familiar place or route in natural surroundings was recorded but it was not related to the assessed post-visit outcomes. The type of activity was recorded but not taken into account in the analyses, however, only 7.7% selected the option 'spending time, viewing, and observing nature', and other activities specified were more physically active (for instance, 33% walking, 20% walking a dog, 12% gardening). Study 4, instead, controlled for the activity and attempted to control for

intensity. All participants walked the same route and were instructed to walk at a calm pace that they were comfortable with. The walk durations ranged between 65 and 155 minutes in Study 4A and 44 and 97 minutes in Study 4B but these durations were not relevant in terms of the outcomes in either study.

As Studies 1-3 were all based solely on self-reported survey data on everyday activities, not only the qualitative differences between the visited settings but also individual differences in what constitutes 'nature' were obviously vast. Studies 1-3 did not assess how environmental quality might moderate the connection between nature visits and well-being although this is an important topic and a priority for future research (Twohig-Bennett & Jones, 2018; M. van den Berg et al., 2015). However, to minimise the influence of individual perceptions of what is 'natural', the questionnaires provided guidelines with definitions at the beginning. For example, the follow-up survey in Study 3 defined 'nature' as 'urban parks, forests, beaches, waters, fields, and various protected areas, for example', and the definition in the main survey used in Studies 1 and 2 was similar. The complexity difficulty in defining 'nature' was, however, evident in Study 4, which was the only study in this thesis able to control for the quality of the natural setting visited. Although the study sites were predominantly coniferous/mixed forest and an urban park, both were situated within sight of some buildings: detached houses in Study 4A and apartments/hospital facilities in Study 4B. Many of the participants were enthusiastic nature visitors to natural settings and in their verbal feedback some stated that they had not perceived the study routes as 'nature', referring to the parts along roads, felled forests and buildings. This exemplifies why the strict categorisation of a single setting or route as 'natural' or 'built' has been criticised (for example, Markevych et al., 2017). The complexity of environmental qualities and perceptions of nature are important but beyond the scope of this thesis, where the environmental categorisation followed the general current practices, thereby facilitating comparison across studies.

All studies were based on Finnish-speaking respondents and participants, thus generalisations of the results to other countries and populations should be made with caution. The main findings that are comparable with earlier studies, such as the notion that mood tends to be more positive after visiting natural settings (Study 4), showed no major differences from the existing evidence (McMahan & Estes, 2015). Nevertheless, accessibility of natural outdoor settings may be an issue in more urbanised countries and cities, whereas access to natural settings is generally good and equal across different regions and demographic groups in Finland (Sievänen & Neuvonen, 2011a). We do not know to what extent the results apply to populations

with less easy access to natural settings. It is also possible that differences in access within the Finnish population are relevant in terms of frequency of visits and their outcomes but we did not assess accessibility in the studies composing this thesis.

Study 4 differed from the others in its design and the measures used, and hence has several limitations that Studies 1-3 do not share. Firstly, as the participants walked by themselves outdoors, there was no control over the events during the nature walk (although this way the experiment had better external validity than, for instance, simulated walks or walks accompanied by the researcher). For example, problems with wayfinding were not anticipated but showed a strong negative connection to the outcomes in Study 4A. In Study 4B we took better account of this by choosing an easier route with GPS navigation tools showing the route and the participant's location. We also added new questions to the questionnaire related to the ease of wayfinding and unusual events during the walk, which were categorised post-hoc as positive (e.g., bumping into an old friend), neutral (e.g., witnessing a wedding ceremony in the park) or negative (e.g., being disturbed by passers-by). However, few participants experienced issues with wayfinding, and the unusual events were not related to the outcomes.

Secondly regarding Study 4, the attention task we used measured sustained attention (also referred to as vigilance), which in most studies has not been found to be restored after nature visits (for a meta-analysis see Stevenson et al., 2018). With this in mind, our results showing improvements in most groups in the attention measures and some between-group differences contrasts with these other findings. SART has not been widely used in experiments in environmental psychology but the question as to what the best measure to assess ART might be is yet to be confirmed (Joye & Dewitte, 2018). Thirdly, we had no control over how the tasks were performed (time spent on each task, changes in perception/interaction with nature that followed) or qualitative information on how they were perceived other than those given in the verbal feedback. Systematically collected qualitative assessments or walk-along interviews with some participants would have been useful for task development and gaining a better understanding of restoration as a process.

4.4 Ethical considerations

At the beginning of these doctoral studies I participated in a compulsory research ethics course (4 ECTS) on the Finnish regulations for research ethics. I started this work on a project funded by the Academy of Finland, thus bound by their ethical

guidelines by following good scientific practices as stipulated by the Finnish Advisory Board on Research Ethics (2012). I have done my best to follow these guidelines throughout the doctoral research process. In this section I present the main ethical issues I have encountered or processed while conducting this research and provide examples of how these issues have been dealt with. These issues can be broadly categorised as those related to how the data is analysed and interpreted, the research environment, humans as study subjects, and open science policies.

4.4.1 Statistical methodology

In the main analyses in all studies I used path modelling and SEM, which that are comprehensive, flexible, and hence in many ways complex (Kline, 2016). How to deal with the complexity has been debated by the methodologists. Issues arise from the assessment of global model fit and potential modifications in the models (Kline, 2016). Another question, prevalent in most (psychological) research, relates to how to shift the focus in the interpretation of the results from statistical significance to effect sizes.

Regarding global model fit assessment in SEM, the χ^2 test is not only the foundation of all fit indices but also a controversial test of model fit. The test most likely rejects all models with a sample size greater than 200 and, as a consequence, many applied researchers ignore this test altogether (Kline, 2016). Nevertheless, the χ^2 test may fail for various reasons, large sample size being only one of them. Ignoring this test, or refusing to inspect and openly discuss the potential sources of misfit could be considered negligence, which is contrary to good scientific practices (Finnish Advisory Board on Research Ethics, 2012). One of the main concerns in this dissertation has been that the χ^2 test rejected all the reported models in Studies 1-3 (nevertheless, other fit indices were acceptable). Is it unethical to infer and draw conclusions when the model does not have an ideal fit? My solution has been to locate the source of misfit by inspecting the model residuals (as recommended by Kline, 2016), adjust the model accordingly, and either report the adjusted model (as in Study 4) or label the adjusted model(s) as sensitivity analyses (as in Study 2) and discuss whether the modification(s) affected the main results of interest. A typical reader is most likely not interested in the technical details of model fit but these approaches were adopted to reduce the risk of misrepresentation, one of the main forms of ethical fraud in science (Finnish Advisory Board on Research Ethics, 2012).

Relatedly, all modifications to the initial models were frankly reported and issues with model fit discussed in all studies.

Psychological research, like most quantitative research, has long been encouraged to shift the focus in the interpretation of results from statistical significance (p-values) to effect sizes (for example, Sharpe, 2013). Addressing this issue is complicated by the fact that appropriate effect size measures vary widely between different types of methods, measures, and even the software used to conduct the analysis (Durlak, 2009). For example, both standardised and unstandardised coefficients can be considered effect size estimates, with methodologists often strongly favouring one or the other (Pek & Flora, 2018). On the other hand, the actions taken to reduce the influential status of p-values, such as banning their reporting altogether, are sometimes deemed too extreme (Sharpe, 2013). P-values and statistical significance do have value in research but it is important to interpret them correctly and remember that they depend on sample size. I have become increasingly aware of this issue during the process of this doctoral thesis and aimed to deal with it to the best of my abilities by open and manysided reporting of the results. In many cases open reporting has been challenging due to the journals' strict word counts, in which case more thorough reporting in appendices was used. The effect size measures reported and discussed in this thesis include, when applicable, variances explained (all studies), both standardised and unstandardised coefficient estimates (Studies 2, 4), standard errors of the estimates (Study 2-4), confidence intervals (Study 2), and mean differences between measurements and groups (Study 4). With topics and measures that have not been widely used in other studies, setting these effect size estimates in context has, nevertheless, been challenging. In most cases I have referred to the general guidelines for social sciences provided by Ferguson (2009). With accumulation of evidence in restorative environments research, the questions on the relative importance of the factors assessed in this thesis will hopefully become easier to evaluate.

4.4.2 Working on a research project

These doctoral studies were conducted as a part of two research projects, a larger consortium project funded by the Academy of Finland, and a smaller project funded by the Kone Foundation. As far as I am aware, recruiting doctoral students (and for that matter postdocs) for larger research projects is common practice in psychological research. This practice has both advantages and disadvantages. When

I began this work on the Academy of Finland project GreenHealth, the project had already started, and the role of the doctoral student had been determined, with the initial topics for three publications agreed on within the consortium. This is standard practice when applying for project funding. However, sometimes in these cases the role of a doctoral student can be quite restricted. It may be necessary to argue for and defend topics, measures, and other choices in scientific forums, such as conferences and journals in which the student was not involved and maybe would not themselves even have selected. Although such cases may not constitute a violation of good scientific practice as such (Finnish Advisory Board on Research Ethics, 2012) and although in my case, they played a minor role, at times I have struggled with the idea that the topics of the publications did not originate from my own ideas. These issues generally, and in this case, were dealt with through co-authorship so that those involved in data collection and in planning the study took part in the publication process or their role was otherwise acknowledged (Finnish Advisory Board on Research Ethics, 2012). My own input was strongest in choosing the methods, conducting the analyses, and in writing and framing the articles.

Using pre-collected data (in Studies 1-3) and studying a topic that did not initially originate from my own ideas also has many advantages, briefly listed here: the process was faster than collecting my own dataset (cf. Study 4, where I carried out the experiment and collected the data); the topics in the thesis that were initiated by my supervisor, a senior scholar in the restorative environments field, address gaps in this otherwise widely studied area; the supervision was no doubt more dedicated and specialised than in a case where the research interests and expertise of doctoral student and supervisor do not coincide; it has given me access to large national datasets which, as an individual doctoral student I would have never had the resources to collect; and maintaining objectivity has been easier with a topic not originating from my personal interests (to the extent that objectivity is achievable).

4.4.3 Issues related to studies on human subjects

In Studies 1–3 the data used did not necessitate obtaining ethical statements due to their non-invasive nature as stated in the guidelines of the Finnish National Advisory Board on Research Ethics (2009). This is common practice with mail surveys in Finland. However, some health science journals see this absence of ethical statements as an anomaly which needs to be justified. Hence, I will now briefly state

the principles of National Advisory Board on Research Ethics (2009) and explain why these features did not apply to Studies 1-3 in this thesis.

- The method for data collection was postal survey and thus did not involve intervention in the physical integrity of subjects.
- Informed consent was obtained passively by attaching introductory letters at the beginning of the questionnaires that explained the purposes of the survey and provided contact details of the data collectors. The recipients were informed that they could freely choose whether to participate in the study or not or discontinue filling in the survey if they so wished. These policies have, however, changed with European Union legislation on data protection that requires more active forms of informed consent (Article 29 Working Party, 2018).
- The studies did not concern children because the survey population was Finnish citizens over the age of 15.
- Participation involved replying to an online or paper questionnaire, which cannot by any standards be considered 'exceptionally strong stimuli'.
- The study is highly unlikely to cause long-term mental harm.
- The topic, "outdoor recreation", was not sensitive and responding to the surveys was anonymous. Thus participation did not expose the subjects to a security risk.

Study 4, on the other hand, was a field experiment that required ethical evaluation before beginning. In Study 4A the ethical statement was obtained from the Ethics Committee of the Tampere Region, and in Study 4B from the Regional Ethics Committee of the Tampere University Hospital catchment area, due to the physiological measures that intervened in the physical integrity of the subjects (heart rate variability and saliva samples; reported elsewhere). Statements were thus obtained separately for both studies and reported in the publication of these studies. Participant recruitment was also conducted as instructed by the ethical board with necessary information given prior to participation and the written informed consents followed the principles of the Declaration of Helsinki.

However, in a couple of the field sessions we encountered some issues in these procedures when one person signed up several people at the same time but either did not deliver all relevant prior information regarding the procedure or eligibility requirements to the other participants or the other people ignored this information. For example, one requirement for participation was that participants could perform basic computer tasks with a mouse and keyboard, yet there were some cases in Study 4A where this condition was not met. In these situations, the participant could fill in

a paper questionnaire containing the self-reported measures but not the attention task. The most extreme case was when a group of six people had been signed up by a single person. When given verbal information about the study, it turned out that the potential participants were not aware of having been recruited for a scientific study but their perception was that they were going for a guided nature walk. Although all signed informed consent forms and the procedure was similar to the other sessions, we took extra time to explain the study and the procedure more carefully and the participants walked the route in pairs. For these reasons, we decided to exclude the whole group ($n = 6$) from the final data; this partly explains our high exclusion rate in Study 4A.

Another ethical issue related to the study of human subjects that may bias the data is so-called participant bias. This means that human participants have expectations about the study and they often, implicitly or explicitly, behave and respond in a way that they think is expected of them (Davis & Bremner, 2006). In Study 4A we encountered an obvious problem with this issue when in the debriefing talk one participant admitted deliberately making errors in the attention task before the nature walk. These responses were, obviously, discarded from the data, whereas similar but more subtle forms of participant bias may have gone undetected. We tried to minimise this bias during the studies by not explicitly explaining the study conditions to the participants. Instead, we merely mentioned that the instructions for the walk might vary and stressed the importance of following one's own instructions.

4.4.4 Open science policies

Questions related to data handling of the datasets for Studies 1-3 were managed by Statistics Finland and the Natural Resources Institute Finland (LUKE), who are responsible for data collection and archiving. Ensuring anonymity is one of the key issues in handling data (Data Management Guidelines). Prior to receiving these datasets, the datasets had already been anonymised so that I would not have been able to identify a single respondent. Accordingly, there is likewise no risk of accidental identification from the published results (which is rarely the case in statistical research when results are presented on a group level). The datasets are managed by LUKE, who may share the data for research purposes and thus the lifespan of the data is secured. Co-archiving the data at the Finnish Social Science Data Archive would, however, probably increase its accessibility and discoverability

for research purposes. This will be the case for the datasets in Study 4, managed by myself and my supervisor after all results have been published. This promotes open science practices and is nowadays required for many self-collected scientific research data.

In line with the policy to publish in open access journals or in an open access format (Academy of Finland, 2019), the papers in this thesis have been made freely available in various ways, depending on funding and the journals' options. Study 1 was published openly available in a hybrid open access format by paying an additional fee after acceptance. Study 4 was published in a gold open access journal where all articles are free to be read by anyone. The author accepted version of Study 3 is freely available in the Tampere University online repository TamPub (green open access), and the same will apply to Study 2 after the journal's embargo period of 24 months. This summary of the thesis will likewise be made openly available in the Tampere University online repository.

4.5 Conclusions

4.5.1 Scientific conclusions and directions for future research

The positive connection between nearby nature and better mental health has been relatively consistent across studies (for instance, van den Bosch & Ode Sang, 2017) but information has been lacking as to whether it is due to use being made of nearby nature (Markevych et al., 2017). Study 1, published in 2014, is still one of the few population-level studies to compare the everyday use of natural outdoor settings versus built indoor and outdoor settings in terms of health and well-being. The main finding was that more frequent PA in natural outdoor settings seems to be connected to better mental health, controlling for PA in other settings and a number of socio-demographic confounders. Mitchell (2013) reached a similar conclusion using a comparable approach but a more detailed categorisation of natural environments. Study 1, furthermore, suggested that PA in all types of outdoor settings is associated with better evaluations of general health. As such studies are still rare, they need to be replicated and confirmed in different countries, taking into account issues of accessibility and the quality of natural outdoor spaces available (Markevych et al., 2017).

The positive connection between visits to natural settings and mental health has been generally explained and justified by repeated restorative experiences defined in two restoration theories, ART and SRT (Hartig et al., 2014; Markevych et al., 2017). However, Study 2 contested this implicit assumption. The results of Study 2 indicated that although restoration tends to be greater in natural than in built settings, the positive nature-well-being connection may not be due to restoration experienced from single bouts of PA. More studies, especially longitudinal ones, are required to confirm this result and assess the contribution of repeated restoration on longer-term well-being. Assessing other mediators in this relationship would also be important to understand their relative contributions (for an example, see de Vries et al., 2013). Furthermore, the need to broaden the theoretical grounds justifying restorative environments research has been explicitly addressed (for example, Hartig, 2018). Instead of basing the research exclusively on ART and SRT, exploratory research, qualitative studies, and theories from other disciplines could be useful ways to expand our conception of the variety of psychological benefits that visits to natural environments potentially induce and help to explain these effects (Hartig, 2018).

Regarding the evaluation of restoration outcomes, Study 2 suggested that ROS9 forms two factors. The first factor, restorativeness, consists of six items based on the dominant restoration theories, ART and SRT, and is thus a more traditional measure of perceived restoration outcomes. The second factor, assurance, based on more recent evidence of visits to restorative natural environments, may help to highlight the positive psychological outcomes of other settings and activities. Our data indicated that one of the items, 'My vitality and energy increased', was ambiguous as it loaded strongly on both factors; prospective studies could consider excluding this item. Naturally, further work is needed to confirm these findings because no single data or study can establish reliable standards for using a scale.

Furthermore, regarding measures of restoration and their evaluation, Study 2 provided an example of how to assess nuanced differences in the quality of restoration in different settings by using measurement invariance methodologies. Most restoration perception and outcome measures have recently been reviewed comprehensively by Han (2018), who evaluated these scales mainly on the basis of their internal consistency, using Cronbach's α, and relationships with other scales based on correlations. Han's (2018) work was a great starting point for measure development in environmental psychology, and it could be extended to a more refined analysis grounded on measurement invariance testing. These methods assess scales more comprehensively from different aspects and are able to overcome much

of the harsh criticism by methodologists about using summary scores instead of latent factors and Cronbach's α as their sole measure of reliability (McNeish, 2018; Marsh, Lüdtke, Nagengast, Morin, & Von Davier, 2013).

What explains restoration and mood changes after a single visit to a natural setting? It seems that psychological factors, motives and attentional focus are important determinants but these have rarely been quantitatively explored. The prominent role of stress reduction as a motive to visit nature, found in Study 3, was expected based on theoretical and empirical work (Ulrich, 1983; A. van den Berg et al., 2007), whereas the mixed findings regarding the motive to be alone were unanticipated and merit more attention in the future. In addition, the stability of different motives and individual trait-level differences in personality and orientation to nature may provide further insight on the determinants of everyday restoration.

Attention and engagement with the environment during visits to natural settings were assessed in Studies 3 and 4. Both studies showed that the topic is complex. While it seems that focusing on the environment and one's own thoughts tend to correlate with positive restorative changes, they are not essential for experiencing restoration. In two field experiments (Study 4), conducting psychological tasks targeting interaction with the environment was associated with some positive changes in sustained attention but these effects were sensitive to the content of the tasks and their order. Thus, more research efforts investigating what kind of tasks are beneficial, for whom and when, are needed to better understand the complexity of person-environment interaction and the associated outcomes. One option could be to develop interventions that promote engagement/interaction with the environment, aiming at constructive rather than ruminative cognitive appraisal. Person-environment interaction is, of course, a broad but theoretically essential aspect (Kaplan & Kaplan, 1989) that merits more emphasis in restorative environments research overall.

Finally, I present recommendations for future research on restorative environments that were covered to some extent in the present studies (see Section 4.3 Limitations) but merit more detailed focus in prospective studies.

- Individual, psychological aspects (that is, a 'top-down' approach) such as personality, current state (such as stressed or bored), and personal memories in restorative perceptions merit more focus (Morton et al., 2017; Ratcliffe & Korpela, 2018)

- Socio-demographic moderators such as age, gender, nationality, and socio-economic status should be better explored, for example, by stratifying models although this needs relatively large samples (Markevych et al., 2017)

- In terms of single visits to natural settings, we do not know how long the restorative effects last and what are the effects of conducting psychological tasks or other forms of engagement with the environment repeatedly over time (Duvall, 2011; Lymeus et al., 2018; Thompson Coon et al., 2011)

- Better attempts should be made to study those that are generally underrepresented either in participation in scientific research (men, younger age groups) and/or outdoor recreation (such as older women in poor health or those with lower socio-economic status, see Boyd et al., 2018 for a detailed analysis)

4.5.2 Practical implications and recommendations

This thesis focused on everyday activities in natural settings and well-being. Taking together the results and earlier studies on similar topics, I conclude this thesis with some practical implications and recommendations (the study addressing the respective point given in parentheses):

- As the frequency of PA in natural settings correlates with emotional well-being and general health, it is important that those wishing to engage in PA outdoors in nature have places where they can do this in their everyday lives. (Study 1)

- Psychological restoration, evaluated by attention restoration and relaxation, tends to be greater after PA in natural outdoor settings than in indoor or built outdoor settings. Experimental evidence suggests that if the same type of activity can be conducted indoors or outdoors, outdoors is preferable for restoration and mood. (Study 2)

- The extent of the differences in restoration in everyday lives, however, are small and activities in other settings may be more beneficial in other ways. In terms of health and well-being, it is more important to be physically active than to be physically active in a specific type of environment. (Studies 1 and 2)

- From the planning perspective, people have different needs and motives for outdoor recreation and hence we need accessible settings that support a range of needs and motives. (Study 3)

- While in natural settings, focusing on natural features tends to be associated with post-visit restoration but this is not the only way to experience restoration. In fact, focusing on one's own thoughts and emotions during a nature visit can be associated with a wider range of perceived benefits. (Study 3)

- Visiting natural settings appears particularly suitable for those who are stressed or feel the need to alleviate stress. Visiting a natural setting, even for a short time, is thus worth trying when feeling stressed. However, stress during such a visit is not conducive to restoration and should be avoided. (Studies 3 and 4)

- Conducting psychological tasks designed to enhance restoration during a single visit to a natural setting may not necessarily add to the perceived benefits of the visit (or, for that matter, reduce them) but it can improve sustained attention. (Study 4)

- Other studies indicate that focusing on greenery may be especially relevant for restoration in urban or built environments. With growing urbanisation, the potential of directed focus and guided engagement with the natural world in more built-up settings is worth trying and further investigating. (Study 4)

REFERENCES

Aalto, A., Aro, A. R., & Teperi, J. (1999). *RAND-36 as a measure of health-related quality of life. reliability, construct validity and reference values in the Finnish general population. [RAND-36 terveyteen liittyvän elämänlaadun mittarina: mittarin luotettavuus ja suomalaiset väestöarvot]*. Helsinki: Stakes.

Abraham, A., Sommerhalder, K., & Abel, T. (2010). Landscape and well-being: A scoping study on the health-promoting impact of outdoor environments. *International Journal of Public Health, 55*(1), 59-69. doi:10.1007/s00038-009-0069-z

Abrahamse, W., Schultz, P. W., & Steg, L. (2016). Research designs for environmental issues. In R. Gifford (Ed.), *Research methods for environmental psychology* (pp. 53-70). Chichester, UK: Wiley Online Library.

Alcock, I., White, M. P., Wheeler, B. W., Fleming, L. E., & Depledge, M. H. (2014). Longitudinal effects on mental health of moving to greener and less green urban areas. *Environmental Science & Technology, 48*(2), 1247-1255. doi:10.1021/es403688w

Ambrey, C. L. (2016). An investigation into the synergistic wellbeing benefits of greenspace and physical activity: Moving beyond the mean. *Urban Forestry & Urban Greening, 19*, 7-12. doi:10.1016/j.ufug.2016.06.020

Ambrey, C. L., & Cartlidge, N. (2017). Do the psychological benefits of greenspace depend on one's personality? *Personality and Individual Differences, 116*, 233-239. doi:10.1016/j.paid.2017.05.001

Annerstedt van den Bosch, Matilda, Östergren, P., Grahn, P., Skärbäck, E., & Währborg, P. (2015). Moving to serene nature may prevent poor mental health—Results from a Swedish longitudinal cohort study. *International Journal of Environmental Research and Public Health, 12*(7), 7974-7989. doi:10.3390/ijerph120707974

Annerstedt, M., Östergren, P., Björk, J., Grahn, P., Skärbäck, E., & Währborg, P. (2012). Green qualities in the neighbourhood and mental health – results from a longitudinal cohort study in southern Sweden. *BMC Public Health, 12*(1), 337. doi:10.1186/1471-2458-12-337

Article 29 Working Party. (2018). *Guidelines on consent under regulation 2016/679*. Retrieved from https://ec.europa.eu/newsroom/article29/item-detail.cfm?item_id=623051

Astell-Burt, T., Mitchell, R., & Hartig, T. (2014). The association between green space and mental health varies across the lifecourse. A longitudinal study. *Journal of Epidemiology & Community Health, 68*(6), 578-583. doi:10.1136/jech-2013-203767

Atchley, R. A., Strayer, D. L., & Atchley, P. (2012). Creativity in the wild: Improving creative reasoning through immersion in natural settings. *PloS One, 7*(12), e51474. doi:10.1371/journal.pone.0051474

Baas, M., De Dreu, Carsten K W, & Nijstad, B. A. (2008). A meta-analysis of 25 years of mood-creativity research: Hedonic tone, activation, or regulatory focus? *Psychological Bulletin, 134*(6), 779-806. doi:10.1037/a0012815

Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science & Technology, 44*(10), 3947-3955. doi:10.1021/es903183r

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin, 107*(2), 238-246.

Beute, F., & de Kort, Yvonne A W. (2014). Salutogenic effects of the environment: Review of health protective effects of nature and daylight. *Applied Psychology: Health and Well-Being, 6*(1), 67-95. doi:10.1111/aphw.12019

Bielinis, E., Omelan, A., Boiko, S., & Bielinis, L. (2018). The restorative effect of staying in a broad- leaved forest on healthy young adults in winter and spring. *Baltic Forestry, 24*(2), 218-227.

Bixler, R. D., & Floyd, M. F. (1997). Nature is scary, disgusting, and uncomfortable. *Environment and Behavior, 29*(4), 443-467. doi:10.1177/001391659702900401

Borodulin, K., Paronen, O., & Männistö, S. (2011). Aikuisten vapaa-ajan liikuntaympäristöt [Settings for leisure-time physical activity in adults]. In P. Husu, O. Paronen, J. Suni & T. Vasankari (Eds.), *Suomalaisten fyysinen aktiivisuus ja kunto 2010: Terveyttä edistävän liikunnan nykytila ja muutokset [Physical activity and fitness of Finns in 2010: Current status and changes in health-enhancing physical activity]* (pp. 61-67). Helsinki: Opetus- ja kulttuuriministeriö.

Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010a). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health, 10*, 456-465. doi:10.1186/1471-2458-10-456

Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010b). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning, 97*(3), 147-155. doi:10.1016/j.landurbplan.2010.05.006

Boyd, F., White, M. P., Bell, S. L., & Burt, J. (2018). Who doesn't visit natural environments for recreation and why: A population representative analysis of spatial, individual and temporal factors among adults in England. *Landscape and Urban Planning, 175*, 102-113. doi:10.1016/j.landurbplan.2018.03.016

Bratman, G. N., Hamilton, J. P., Hahn, K. S., Daily, G. C., & Gross, J. J. (2015). Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proceedings of the National Academy of Sciences, 112*(28), 8567-8572. doi:10.1073/pnas.1510459112

Brooks, A. M., Ottley, K. M., Arbuthnott, K. D., & Sevigny, P. (2017). Nature-related mood effects: Season and type of nature contact. *Journal of Environmental Psychology, 54*, 91-102. doi:10.1016/j.jenvp.2017.10.004

Browne, M. W., & Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociological Methods & Research, 21*(2), 230-258.

Byrka, K., & Ryczko, N. (2018). Positive effects of dancing in natural versus indoor settings: The mediating role of engagement in physical activity. *Journal of Environmental Psychology, 57*, 25-33. doi:10.1016/j.jenvp.2018.06.002

Calogiuri, G., & Elliott, L. (2017). Why do people exercise in natural environments? Norwegian adults' motives for nature-, gym-, and sports-based exercise. *International Journal of Environmental Research and Public Health, 14*(4), 377. doi:10.3390/ijerph14040377

Cameron-Faulkner, T., Melville, J., & Gattis, M. (2018). Responding to nature: Natural environments improve parent-child communication. *Journal of Environmental Psychology, 59*, 9-15. doi:10.1016/j.jenvp.2018.08.008

Collado, S., Staats, H., Corraliza, J. A., & Hartig, T. (2017). Restorative environments and health. In G. Fleury-Bahi, E. Pol & O. Navarro (Eds.), *Handbook of environmental psychology and quality of life research* (pp. 127-148). Cham: Springer.

Cooper, C. (1998). Individual differences. London: Arnold.

Finnish Social Science Data Archive (2015). *Data management guidelines* [online guide]. Tampere: Finnish Social Science Data Archive [distributor and producer]. Retrieved from http://www.fsd.uta.fi/aineistonhallinta/en/

Davis, A., & Bremner, G. (2006). The experimental method in psychology. In G. M. Breakwell, S. Hammond, C. Fife-Schaw & J. A. Smith (Eds.), *Research methods in psychology* (3rd ed., pp. 64-87). London: Sage.

de Vries, S., van Dillen, Sonja M E, Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine, 94*(0), 26-33. doi:10.1016/j.socscimed.2013.06.030

Durlak, J. A. (2009). How to select, calculate, and interpret effect sizes. *Journal of Pediatric Psychology, 34*(9), 917-928. doi:10.1093/jpepsy/jsp004

Duvall, J. (2011). Enhancing the benefits of outdoor walking with cognitive engagement strategies. *Journal of Environmental Psychology, 31*(1), 27-35. doi:10.1080/02699930441000238

Duvall, J. (2013). Using engagement-based strategies to alter perceptions of the walking environment. *Environment and Behavior, 45*(3), 303-322. doi:10.1177/0013916511423808

Elliott, L. R., White, M. P., Taylor, A. H., & Herbert, S. (2015). Energy expenditure on recreational visits to different natural environments. *Social Science & Medicine, 139*, 53-60. doi:10.1016/j.socscimed.2015.06.038

Ferguson, C. J. (2009). An effect size primer: A guide for clinicians and researchers. *Professional Psychology: Research and Practice, 40*(5), 532-538. doi:10.1037/a0015808

Fife-Schaw, C. (2006). Quasi-experimental designs. In G. Breakwell, S. M. Hammond, C. Fife-Schaw & J. A. Smith (Eds.), *Research methods in psychology* (3rd ed., pp. 88-103). London: Sage.

Finnish Advisory Board on Research Ethics (2012). *Responsible conduct of research and procedures for handling allegations of misconduct in Finland.* Guidelines of the Finnish Advisory Board on Research Integrity 2012.

Fleury-Bahi, G., Fleury-Bahi, G., Pol, E., & Navarro, O. (2017). *Handbook of environmental psychology and quality of life research.* Cham: Springer.

Fox, K. R. (1999). The influence of physical activity on mental well-being. *Public Health Nutrition, 2*(3a), 411-418. doi: 10.1017/S1368980099000567

Franco, L. S., Shanahan, D. F., & Fuller, R. A. (2017). A review of the benefits of nature experiences: More than meets the eye. *International Journal of Environmental Research and Public Health, 14*(8), 864. doi:10.3390/ijerph14080864

Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Forns, J., Plasència, A., & Nieuwenhuijsen, M. (2015). Mental health benefits of long-term exposure to residential green and blue spaces: A systematic review. *International Journal of Environmental Research and Public Health, 12*(4), 4354-4379. doi:10.3390/ijerph120404354

Gascon, M., Zijlema, W., Vert, C., White, M. P., & Nieuwenhuijsen, M. J. (2017). Outdoor blue spaces, human health and well-being: A systematic review of quantitative studies. *International Journal of Hygiene and Environmental Health, 220*(8), 1207-1221. doi:10.1016/j.ijheh.2017.08.004

Gatersleben, B., & Andrews, M. (2013). When walking in nature is not restorative - The role of prospect and refuge. *Health & Place, 20*, 91-101. doi:10.1016/j.healthplace.2013.01.001

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality & Social Psychology, 85*(2), 348-362. doi:10.1037/0022-3514.85.2.348

Haga, A., Halin, N., Holmgren, M., & Sörqvist, P. (2016). Psychological restoration can depend on stimulus-source attribution: A challenge for the evolutionary account? *Frontiers in Psychology, 7*, 1831. doi:10.3389/fpsyg.2016.01831

Hagstromer, M., Ainsworth, B. E., Oja, P., & Sjostrom, M. (2010). Comparison of a subjective and an objective measure of physical activity in a population sample. *Journal of Physical Activity and Health, 7*(4), 541-550. doi:10.1123/jpah.7.4.541

Han, K. (2017). The effect of nature and physical activity on emotions and attention while engaging in green exercise. *Urban Forestry & Urban Greening, 24*, 5-13. doi:10.1016/j.ufug.2017.03.012

Han, K. (2018). A review of self-report scales on restoration and/or restorativeness in the natural environment. *Journal of Leisure Research, 49*(3-5), 151-176. doi:10.1080/00222216.2018.1505159

Han, K., & Wang, P. (2018). Empirical examinations of effects of three-level green exercise on engagement with nature and physical activity. *International Journal of Environmental Research and Public Health, 15*(2), 375. doi:10.3390/ijerph15020375

Hartig, T., Lindblom, K., & Ovefelt, K. (1998). The home and near-home area offer restoration opportunities differentiated by gender. *Scandinavian Housing and Planning Research, 15*(4), 283-296. doi:10.1080/02815739808730463

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health, 35*(1), 207-228. doi:10.1146/annurev-publhealth-032013-182443

Hartig, T., & Staats, H. (2006). The need for psychological restoration as a determinant of environmental preferences. *Journal of Environmental Psychology, 26*(3), 215-226. doi:10.1016/j.jenvp.2006.07.007

Hays, R. D., Sherbourne, C. D., & Mazel, R. M. (1993). The RAND 36-item health survey 1.0. *Health Economics, 2*(3), 217-227. doi:10.1002/hec.4730020305

Herzog, T. R., Black, A. M., Fountaine, K. A., & Knotts, D. J. (1997). Reflection and attentional recovery as distinctive benefits of restorative environments. *Journal of Environmental Psychology, 17*(2), 165-170. doi:10.1006/jevp.1997.0051

Hine, D. W., Corral-Verdugo, V., Bhullar, N., & Frias-Armenta, M. (2016). Advanced statistics for Environment-Behavior research. In R. Gifford (Ed.), *Research methods for environmental psychology* (pp. 369-388). Chichester, UK: Wiley Online Library.

Hirabayashi, S., & Nowak, D. J. (2016). Comprehensive national database of tree effects on air quality and human health in the United States. *Environmental Pollution, 215*, 48-57. doi:10.1016/j.envpol.2016.04.068

Hough, R. L. (2014). Biodiversity and human health: Evidence for causality? *Biodiversity and Conservation, 23*(2), 267–288. doi:10.1007/s10531-013-0614-1

Houlden, V., Weich, S., Porto de Albuquerque, J., Jarvis, S., & Rees, K. (2018). The relationship between greenspace and the mental wellbeing of adults: A systematic review. *Plos One, 13*(9), e0203000. doi:10.1371/journal.pone.0203000

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55. doi: 10.1080/10705519909540118

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

Husu, P., Paronen, O., Suni, J., & Vasankari, T. (2011). *Suomalaisten fyysinen aktiivisuus ja kunto 2010: Terveyttä edistävän liikunnan nykytila ja muutokset [Physical activity and fitness of Finns in 2010: Current status and changes in health-enhancing physical activity]*. Opetus- ja kulttuuriministeriön julkaisuja 2011:15.

Idler, E. L., & Benyamini, Y. (1997). Self-rated health and mortality: A review of twenty-seven community studies. *Journal of Health and Social Behavior, 38*(1), 21-37. doi:10.2307/2955359

Irvine, K., Warber, S., Devine-Wright, P., & Gaston, K. (2013). Understanding urban green space as a health resource: A qualitative comparison of visit motivation and derived effects among park users in Sheffield, UK. *International Journal of Environmental Research and Public Health, 10*(1), 417-442. doi:10.3390/ijerph10010417

James, P., Banay, R. F., Hart, J. E., & Laden, F. (2015). A review of the health benefits of greenness. *Current Epidemiology Reports, 2*(2), 131–142. doi: 10.1007/s40471-015-0043-7

Johansson, M., Hartig, T., & Staats, H. (2011). Psychological benefits of walking: Moderation by company and outdoor environment. *Applied Psychology: Health and Well-Being, 3*(3), 261-280. doi:10.1111/j.1758-0854.2011.01051.x

Johnson, K. A., Kelly, S. P., Bellgrove, M. A., Barry, E., Cox, M., Gill, M., & Robertson, I. H. (2007). Response variability in attention deficit hyperactivity disorder: Evidence for neuropsychological heterogeneity. *Neuropsychologia, 45*(4), 630-638. doi:10.1016/j.neuropsychologia.2006.03.034

Joye, Y., & Dewitte, S. (2018). Nature's broken path to restoration. A critical look at attention restoration theory. *Journal of Environmental Psychology, 59*, 1-8. doi:10.1016/j.jenvp.2018.08.006

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:10.1016/0272-4944(95)90001-2

Kaplan, S. (2001). Meditation, restoration, and the management of mental fatigue. *Environment and Behavior, 33*(4), 480-506. doi:10.1177/00139160121973106

Karmanov, D., & Hamel, R. (2008). Assessing the restorative potential of contemporary urban environment(s): Beyond the nature versus urban dichotomy. *Landscape and Urban Planning, 86*(2), 115-125. doi:10.1016/j.landurbplan.2008.01.004

Kassavou, A., French, D. P., & Chamberlain, K. (2015). How do environmental factors influence walking in groups? A walk-along study. *Journal of Health Psychology, 20*(10), 1328-1339. doi:10.1177/1359105313511839

Kelley, K., & Preacher, K. J. (2012). On effect size. *Psychological Methods, 17*(2), 137-152. doi:10.1037/a0028086

Keniger, L. E., Gaston, K. J., Irvine, K. N., & Fuller, R. A. (2013). What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health, 10*(3), 913-935. doi:10.3390/ijerph10030913

Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). New York: Guilford Press.

Klompmaker, J. O., Hoek, G., Bloemsma, L. D., Gehring, U., Strak, M., Wijga, A. H., van den Brink, C., Brunekreef, B., Lebret, E., & Janssen, N. A. H. (2018). Green space definition affects associations of green space with overweight and physical activity. *Environmental Research, 160*, 531-540. doi:10.1016/j.envres.2017.10.027

Knopf, R. C. (1987). Human behavior, cognition, and affect in the natural environment. In D. Stokols, & I. Altman (Eds.), *Handbook of environmental psychology, Volume 1* (pp. 783-825). New York: Wiley.

Kondo, M., Fluehr, J., McKeon, T., & Branas, C. (2018). Urban green space and its impact on human health. *International Journal of Environmental Research and Public Health, 15*(3), 445. doi:10.3390/ijerph15030445

Kondo, M. C., Jacoby, S. F., & South, E. C. (2018). Does spending time outdoors reduce stress? A review of real-time stress response to outdoor environments. *Health and Place, 51*, 136-150. doi:10.1016/j.healthplace.2018.03.001

Korpela, K., Borodulin, K., Neuvonen, M., Paronen, O., & Tyrväinen, L. (2014). Analyzing the mediators between nature-based outdoor recreation and emotional well-being. *Journal of Environmental Psychology, 37*, 1-7. doi:10.1016/j.jenvp.2013.11.003

Korpela, K., Savonen, E.-M., Anttila, S., Pasanen, T., & Ratcliffe, E. (2017). Enhancing wellbeing with psychological tasks along forest trails. *Urban Forestry and Urban Greening, 26*, 25-30. doi:10.1016/j.ufug.2017.06.004

Korpela, K. M. (1992). Adolescents' favourite places and environmental self-regulation. *Journal of Environmental Psychology, 12*(3), 249-258.

Korpela, K. M., Pasanen, T., Repo, V., Hartig, T., Staats, H., Mason, M., Alves, S., Fornara, F., Marks, T., Saini, S., Scopelliti, M., Soares, A. L., Stigsdotter, U. K., & Ward Thompson, C. (2018). Environmental strategies of affect regulation and their associations with subjective well-being. *Frontiers in Psychology, 9*, 562. doi:10.3389/fpsyg.2018.00562

Korpela, K. M., Stengård, E., & Jussila, P. (2016). Nature walks as a part of therapeutic intervention for depression. *Ecopsychology, 8*(1), 8-15. doi:10.1089/eco.2015.0070

Korpela, K. M., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2008). Determinants of restorative experiences in everyday favorite places. *Health & Place, 14*(4), 636-652. doi:10.1016/j.healthplace.2007.10.008

Korpela, K. M., & Ylén, M. P. (2009). Effectiveness of favorite-place prescriptions: A field experiment. *American Journal of Preventive Medicine, 36*(5), 435-438. doi:10.1016/j.amepre.2009.01.022

Korpela, K., De Bloom, J., Sianoja, M., Pasanen, T., & Kinnunen, U. (2017). Nature at home and at work: Naturally good? links between window views, indoor plants, outdoor activities and employee well-being over one year. *Landscape and Urban Planning, 160*, 38-47. doi:10.1016/j.landurbplan.2016.12.005

Kuo, M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Frontiers in Psychology, 6,* 1093. doi:10.3389/fpsyg.2015.01093

Lin, B. B., Fuller, R. A., Bush, R., Gaston, K. J., & Shanahan, D. F. (2014). Opportunity or orientation? Who uses urban parks and why. *Plos One, 9*(1), e87422. doi:10.1371/journal.pone.0087422

Lin, Y., Tsai, C., Sullivan, W. C., Chang, P., & Chang, C. (2014). Does awareness effect the restorative function and perception of street trees? *Frontiers in Psychology, 5*, 906. doi:10.3389/fpsyg.2014.00906

Linley, P. A., Maltby, J., Wood, A. M., Osborne, G., & Hurling, R. (2009). Measuring happiness: The higher order factor structure of subjective and psychological well-being measures. *Personality and Individual Differences, 47*(8), 878-884. doi:10.1016/j.paid.2009.07.010

Lymeus, F., Lindberg, P., & Hartig, T. (2018). Building mindfulness bottom-up: Meditation in natural settings supports open monitoring and attention restoration. *Consciousness and Cognition, 59*, 40-56. doi:10.1016/j.concog.2018.01.008

Manly, T., Owen, A. M., McAvinue, L., Datta, A., Lewis, G. H., Scott, S. K., Rorden, C., Pickard, J., & Robertson, I. H. (2003). Enhancing the sensitivity of a sustained attention task to frontal damage: Convergent clinical and functional imaging evidence. *Neurocase, 9*(4), 340-349. doi:10.1076/neur.9.4.340.15553

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., de Vries, S., Triguero-Mas, M., Brauer, M., Nieuwenhuijsenh, M., J., Lupp, G., Richardson, E. A. Astell-Burt, T., Dimitrova, D., Feng, X., Sadeh, M., Standl, M., Heinrich, J., & Fuertes, E. (2017). Exploring pathways linking greenspace to health: Theoretical and methodological guidance. *Environmental Research, 158*, 301-317. doi:10.1016/j.envres.2017.06.028

Marsh, H. W., Lüdtke, O., Nagengast, B., Morin, A. J., & Von Davier, M. (2013). Why item parcels are (almost) never appropriate: Two wrongs do not make a right—Camouflaging misspecification with item parcels in CFA models. *Psychological Methods, 18*(3), 257-284. doi:10.1037/a0032773

McIntyre, N., & Roggenbuck, J. (1998). Nature/person transactions during an outdoor adventure experience: A multi-phasic analysis. *Journal of Leisure Research, 30*(4), 401-422.

McMahan, E. A., & Estes, D. (2015). The effect of contact with natural environments on positive and negative affect: A meta-analysis. *The Journal of Positive Psychology, 10*(6), 507-519. doi:10.1080/17439760.2014.994224

McNeish, D. (2018). Thanks coefficient alpha, we'll take it from here. *Psychological Methods, 23*(3), 412-433. doi:10.1037/met0000144

Miilunpalo, S., Vuori, I., Oja, P., Pasanen, M., & Urponen, H. (1997). Self-rated health status as a health measure: The predictive value of self-reported health status on the use of physician services and on mortality in the working-age population. *Journal of Clinical Epidemiology, 50*(5), 517-528. doi:10.1016/S0895-4356(97)00045-0

Mitchell, R. (2013). Is physical activity in natural environments better for mental health than physical activity in other environments? *Social Science & Medicine, 91*, 130-134. doi:10.1016/j.socscimed.2012.04.012

Mitchell, R., & Popham, F. (2008). Effect of exposure to natural environment on health inequalities: An observational population study. *The Lancet, 372*(9650), 1655-1660. doi:10.1016/S0140-6736(08)61689-X

Morton, T. A., van der Bles, Anne Marthe, & Haslam, S. A. (2017). Seeing our self reflected in the world around us: The role of identity in making (natural) environments restorative. *Journal of Environmental Psychology, 49*, 65-77. doi: 10.1016/j.jenvp.2016.11.002

Muthén, L. K., & Muthén, B. O. (1998-2017). *Mplus user's guide* (8th ed.). Los Angeles, CA: Muthén & Muthén.

National Advisory Board on Research Ethics. (2009). *Ethical principles of research in the humanities and social and behavioural sciences and proposals for ethical review*. Helsinki: National Advisory Board on Research Ethics. Retrieved from https://www.tenk.fi/en/ethical-review-in-finland

Natural Resources Institute Finland. (2018). *Metsävarat [Forest resources]*. Retrieved from https://stat.luke.fi/metsavarat

Nisbet, E. K., & Zelenski, J. M. (2013). The NR-6: A new brief measure of nature relatedness. *Frontiers in Psychology, 4*, 813. doi:10.3389/fpsyg.2013.00813

Ohly, H., White, M. P., Wheeler, B. W., Bethel, A., Ukoumunne, O. C., Nikolaou, V., & Garside, R. (2016). Attention restoration theory: A systematic review of the attention restoration potential of exposure to natural environments. *Journal of Toxicology and Environmental Health, Part B, 19*(7), 305-343. doi:10.1080/10937404.2016.1196155

Pasanen, T. P., Ojala, A., Tyrväinen, L., & Korpela, K. M. (2018). Restoration, well-being, and everyday physical activity in indoor, built outdoor and natural outdoor settings. *Journal of Environmental Psychology, 59*, 85-93. doi:10.1016/j.jenvp.2018.08.014

Pasanen, T. P., Neuvonen, M., & Korpela, K. M. (2018). The psychology of recent nature visits: (How) are motives and attentional focus related to post-visit restorative experiences, creativity, and emotional well-being? *Environment and Behavior, 50*(8), 913-944. doi:10.1177/0013916517720261

Pasanen, T., Johnson, K., Lee, K., & Korpela, K. (2018). Can nature walks with psychological tasks improve mood, self-reported restoration, and sustained attention? Results from two experimental field studies. *Frontiers in Psychology, 9*, 2057. doi:10.3389/fpsyg.2018.02057

Pedersen, A. B., Mikkelsen, E. M., Cronin-Fenton, D., Kristensen, N. R., Pham, T. M., Pedersen, L., & Petersen, I. (2017). Missing data and multiple imputation in clinical epidemiological research. *Clinical Epidemiology, 9*, 157-166. doi:10.2147/CLEP.S129785

Peirce, J. W. (2009). Generating stimuli for neuroscience using PsychoPy. Frontiers in *Neuroinformatics, 2*(10). doi:10.3389/neuro.11.010.2008

Pek, J., & Flora, D. B. (2018). Reporting effect sizes in original psychological research: A discussion and tutorial. *Psychological Methods, 23*(2), 208-225. doi:10.1037/met0000126

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry, 18*(2), 189-193.

Pyky, R., Neuvonen, M., Kangas, K., Ojala, A., Lanki, T., Borodulin, K., & Tyrväinen, L. (2019). Individual and environmental factors associated with green exercise in urban and suburban areas. *Health & Place, 55*, 20-28. doi:10.1016/j.healthplace.2018.11.001

Ratcliffe, E., & Korpela, K. M. (2018). Time- and self-related memories predict restorative perceptions of favorite places via place identity. *Environment and Behavior, 50*(6), 690-720. doi:10.1177/0013916517712002

Reed, J., & Buck, S. (2009). The effect of regular aerobic exercise on positive-activated affect: A meta-analysis. *Psychology of Sport & Exercise, 10*(6), 581-594. doi:10.1016/j.psychsport.2009.05.009

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). `Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia, 35*(6), 747-758. doi:10.1016/S0028-3932(97)00015-8

Rogerson, M., Brown, D. K., Sandercock, G., Wooller, J., & Barton, J. (2016). A comparison of four typical green exercise environments and prediction of psychological health outcomes. *Perspectives in Public Health, 136*(3), 171-180. doi:10.1177/1757913915589845

Rogerson, M., Gladwell, V. F., Gallagher, D. J., & Barton, J. L. (2016). Influences of green outdoors versus indoors environmental settings on psychological and social outcomes of controlled exercise. *International Journal of Environmental Research and Public Health, 13*(4), 363. doi:10.3390/ijerph13040363

Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). Affect grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology, 57*(3), 493-502.

Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. *Annual Review of Psychology, 52*(1), 141-166. doi:10.1146/annurev.psych.52.1.141

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78. doi: 10.1037110003-066X.55.1.68

Ryan, R. M., & Frederick, C. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality, 65*(3), 529-565. doi:10.1111/1467-6494.ep9710314567

Ryan, R. M., Weinstein, N., Bernstein, J., Brown, K. W., Mistretta, L., & Gagné, M. (2010). Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology, 30*(2), 159-168. doi:10.1016/j.jenvp.2009.10.009

Ryff, C. D. (2018). Well-being with soul: Science in pursuit of human potential. *Perspectives on Psychological Science, 13*(2), 242-248. doi:10.1177/1745691617699836

San Juan, C., Subiza-Pérez, M., & Vozmediano, L. (2017). Restoration and the city: The role of public urban squares. *Frontiers in Psychology, 8*. doi:10.3389/fpsyg.2017.02093

Shanahan, D. F., Franco, L., Lin, B. B., Gaston, K. J., & Fuller, R. A. (2016). The benefits of natural environments for physical activity. *Sports Medicine, 46*(7), 989-995. doi: 10.1007/s40279-016-0502-4

Sharpe, D. (2013). Why the resistance to statistical innovations? Bridging the communication gap. *Psychological Methods, 18*(4), 572. doi:10.1037/a0034177

Sievänen, T., & Neuvonen, M. (2011a). Luonnon virkistyskäytön kysyntä 2010 ja kysynnän muutos [Outdoor recreation demand 2010 and changes in the demand]. In T. Sievänen, & M. Neuvonen (Eds.), *Luonnon virkistyskäyttö 2010 [Outdoor recreation 2010]* (pp. 37-73). Vantaa: Metsäntutkimuslaitos.

Sievänen, T., & Neuvonen, M. (2011b). *Luonnon virkistyskäyttö 2010 [Outdoor recreation 2010]*. (Metlan työraportteja / Working Papers of the Finnish Forest Research Institute No. 212). Vantaa: Metsäntutkimuslaitos.

Siniscalchi, J. M., Kimmel, K. D., Couturier, L. E., & Murray, R. (2011). Stress management and the motives of restorative events at the United States Coast Guard Academy. *Military Psychology, 23*(3), 332-349. doi:10.1080/08995605.2011.570601

Smilek, D., Carriere, J. S. A., & Cheyne, J. A. (2010). Failures of sustained attention in life, lab, and brain: Ecological validity of the SART. *Neuropsychologia, 48*(9), 2564-2570. doi:10.1016/j.neuropsychologia.2010.05.002

Spector, P. E. (2019). Do not cross me: Optimizing the use of cross-sectional designs. *Journal of Business and Psychology, 34*(2), 125–137. doi:10.1007/s10869-018-09613-8

Staats, H., & Hartig, T. (2004). Alone or with a friend: A social context for psychological restoration and environmental preferences. *Journal of Environmental Psychology, 24*(2), 199-211. doi:10.1016/j.jenvp.2003.12.005

Staats, H., Kieviet, A., & Hartig, T. (2003). Where to recover from attentional fatigue: An expectancy-value analysis of environmental preference. *Journal of Environmental Psychology, 23*(2), 147-157. doi: 10.1016/S0272-4944(02)00112-3

Statistics Finland. (2019). *Ympäristö ja luonnonvarat [Environment and natural resources]*. Retrieved from http://www.stat.fi/tup/suoluk/suoluk_alue.html

Stevenson, M. P., Schilhab, T., & Bentsen, P. (2018). Attention restoration theory II: A systematic review to clarify attention processes affected by exposure to natural environments. *Journal of Toxicology and Environmental Health. Part B, Critical Reviews, 21*(4), 227-268. doi:10.1080/10937404.2018.1505571

Stewart, W. P., & Hull, R. B. (1996). Capturing the moments: Concerns of in situ leisure research. *Journal of Travel & Tourism Marketing, 5*(1-2), 3-20.

Stigsdotter, U. K., Ekholm, O., Schipperijn, J., Toftager, M., Kamper-Jørgensen, F., & Randrup, T. B. (2010). Health promoting outdoor environments - Associations between green space, and health, health-related quality of life and stress based on a Danish national representative survey. *Scandinavian Journal of Public Health, 38*(4), 411-417. doi:10.1177/1403494810367468

Stigsdotter, U. K., & Grahn, P. (2011). Stressed individuals' preferences for activities and environmental characteristics in green spaces. *Urban Forestry & Urban Greening, 10*(4), 295-304. doi:10.1016/j.ufug.2011.07.001

Stothart Cary. (2015). *Python SART* (Version 2) [software]. Retrieved from https://github.com/cstothart/sustained-attention-to-response-task

Sugiyama, T., Leslie, E., Giles-Corti, B., & Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: Do walking, social coherence and local social interaction explain the relationships? *Journal of Epidemiology & Community Health, 62*(5), e9. doi: 10.1136/jech.2007.064287

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:10.1021/es102947t

Tucker, L. R., & Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika, 38*(1), 1-10. doi:10.1007/BF02291170

Turner, T. L., & Stevinson, C. (2017). Affective outcomes during and after high-intensity exercise in outdoor green and indoor gym settings. *International Journal of Environmental Health Research, 27*(2), 106-116. doi:10.1080/09603123.2017.1282605

Twohig-Bennett, C., & Jones, A. (2018). The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. *Environmental Research, 166*, 628-637. doi:10.1016/j.envres.2018.06.030

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., & Kagawa, T. (2014). The influence of urban green environments on stress relief measures: A field experiment. *Journal of Environmental Psychology, 38*, 1-9. doi:10.1016/j.jenvp.2013.12.005

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. *Human Behavior & Environment: Advances in Theory & Research, 6*, 85-125.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*(3), 201-230. doi:10.1016/S0272-4944(05)80184-7

United Nations (2018). *World urbanization prospects: The 2018 revision.* United nations, Department of Economic and Social Affairs, Population Division. Retrieved from https://population.un.org/wup/

van den Berg, Agnes E., Hartig, T., & Staats, H. (2007). Preference for nature in urbanized societies: Stress, restoration, and the pursuit of sustainability. *Journal of Social Issues, 63*(1), 79-96. doi:10.1111/j.1540-4560.2007.00497.x

Van den Berg, Agnes E., Jorgensen, A., & Wilson, E. R. (2014). Evaluating restoration in urban green spaces: Does setting type make a difference? *Landscape and Urban Planning, 127*, 173-181. doi:10.1016/j.landurbplan.2014.04.012

van den Berg, M., van Poppel, M., Smith, G., Triguero-Mas, M., Andrusaityte, S., van Kamp, I., van Mechelen, W., Gidlow, C., Gražulevičiene, R., Nieuwenhuijsen, M. J., Kruize, H., & Maas, J. (2017). Does time spent on visits to green space mediate the associations between the level of residential greenness and mental health? *Urban Forestry & Urban Greening, 25*, 94-102. doi:10.1016/j.ufug.2017.04.010

van den Berg, M., Wendel-Vos, W., van Poppel, M., Kemper, H., van Mechelen, W., & Maas, J. (2015). Health benefits of green spaces in the living environment: A systematic review of epidemiological studies. *Urban Forestry & Urban Greening, 14*(4), 806-816. doi:10.1016/j.ufug.2015.07.008

van den Bosch, M., & Ode Sang, Å. (2017). Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews. *Environmental Research, 158*, 373-384. doi:10.1016/j.envres.2017.05.040

van Dillen, Sonja M E, de Vries, S., Groenewegen, P. P., & Spreeuwenberg, P. (2012). Greenspace in urban neighbourhoods and residents' health: Adding quality to quantity. *Journal of Epidemiology and Community Health, 66*(6), e8. doi:10.1136/jech.2009.104695

Van Renterghem, T., Forssén, J., Attenborough, K., Jean, P., Defrance, J., Hornikx, M., & Kang, J. (2015). Using natural means to reduce surface transport noise during propagation outdoors. *Applied Acoustics, 92*, 86-101. doi:10.1016/j.apacoust.2015.01.004

Västfjäll, D., & Gärling, T. (2007). Validation of a Swedish short self-report measure of core affect. Scandinavian *Journal of Psychology, 48*(3), 233-238. doi:10.1111/j.1467-9450.2007.00595.x

Vigo, D., Thornicroft, G., & Atun, R. (2016). Estimating the true global burden of mental illness. *The Lancet Psychiatry, 3*(2), 171-178. doi:10.1016/S2215-0366(15)00505-2

Virtanen, V., Nyberg, R., Salonen, R., Neuvonen, M., & Sievänen, T. (2011). LVVI 2 - seurantatutkimuksen aineisto ja menetelmät [The data and methods of the LVVI2 follow-up survey]. In T. Sievänen, & M. Neuvonen (Eds.), *Luonnon virkistyskäyttö 2010 [Outdoor recreation 2010]* (pp. 19-36). Vantaa: Metsäntutkimuslaitos.

Ward Thompson, C., & Aspinall, P. A. (2011). Natural environments and their impact on activity, health, and quality of life. *Applied Psychology: Health and Well-Being, 3*(3), 230-260. doi:10.1111/j.1758-0854.2011.01053.x

Wheeler, B. W., White, M., Stahl-Timmins, W., & Depledge, M. H. (2012). Does living by the coast improve health and wellbeing? *Health & Place, 18*(5), 1198-1201. doi:10.1016/j.healthplace.2012.06.015

White, M. P., Alcock, I., Wheeler, B. W., & Depledge, M. H. (2013). Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. *Psychological Science, 24*(6), 920-928. doi:10.1177/0956797612464659

White, M. P., Pahl, S., Ashbullby, K., Herbert, S., & Depledge, M. H. (2013). Feelings of restoration from recent nature visits. *Journal of Environmental Psychology, 35*, 40-51. doi:10.1016/j.jenvp.2013.04.002

White, M. P., Pahl, S., Wheeler, B. W., Depledge, M. H., & Fleming, L. E. (2017). Natural environments and subjective wellbeing: Different types of exposure are associated with different aspects of wellbeing. *Health & Place, 45*, 77-84. doi:10.1016/j.healthplace.2017.03.008

Williams, K. J. H., Lee, K. E., Hartig, T., Sargent, L. D., Williams, N. S. G., & Johnson, K. A. (2018). Conceptualising creativity benefits of nature experience: Attention restoration and mind wandering as complementary processes. *Journal of Environmental Psychology, 59*, 36-45. doi: 10.1016/j.jenvp.2018.08.005

Wirtz, D., Kruger, J., Napa Scollon, C., & Diener, E. (2003). What to do on spring break? The role of predicted, on-line, and remembered experience in future choice. *Psychological Science, 14*(5), 520-524. doi:10.1111/1467-9280.03455

Wooller, J. J., Rogerson, M., Barton, J., Micklewright, D., & Gladwell, V. (2018). Can simulated green exercise improve recovery from acute mental stress? *Frontiers in Psychology, 9*, 2167. doi:10.3389/fpsyg.2018.02167

World Health Organization. (1946). *Constitution of the world health organization.* Retrieved from https://www.who.int/about/mission/en/

World Health Organization. (2016). *Urban green spaces and health: A review of evidence.* Copenhagen: WHO Regional Office for Europe. Retrieved from http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2016/urban-green-spaces-and-health-a-review-of-evidence-2016

World Health Organization. (2018). *Physical activity.* Retrieved from https://www.who.int/news-room/fact-sheets/detail/physical-activity

Yu, C. (2002). *Evaluating cutoff criteria of model fit indices for latent variable models with binary and continuous outcomes* (Doctoral thesis). University of California. Retrieved from http://statmodel2.com/download/Yudissertation.pdf

Zelenski, J. M., & Larsen, R. J. (2000). The distribution of basic emotions in everyday life: A state and trait perspective from experience sampling data. *Journal of Research in Personality, 34*(2), 178-197. doi:10.1006/jrpe.1999.2275

PUBLICATIONS

PUBLICATION I

The Relationship between Perceived Well-Being and Physical Activity Indoors, Outdoors in Built Environments, and Outdoors in Nature

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The Relationship between Perceived Health and Physical Activity Indoors, Outdoors in Built Environments, and Outdoors in Nature

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Background: A body of evidence shows that both physical activity and exposure to nature are connected to improved general and mental health. Experimental studies have consistently found short term positive effects of physical activity in nature compared with built environments. This study explores whether these benefits are also evident in everyday life, perceived over repeated contact with nature. The topic is important from the perspectives of city planning, individual well-being, and public health. **Methods:** National survey data (n = 2,070) from Finland was analysed using structural regression analyses. Perceived general health, emotional well-being, and sleep quality were regressed on the weekly frequency of physical activity indoors, outdoors in built environments, and in nature. Socioeconomic factors and other plausible confounders were controlled for. **Results:** Emotional well-being showed the most consistent positive connection to physical activity in nature, whereas general health was positively associated with physical activity in both built and natural outdoor settings. Better sleep quality was weakly connected to frequent physical activity in nature, but the connection was outweighed by other factors. **Conclusion:** The results indicate that nature provides an added value to the known benefits of physical activity. Repeated exercise in nature is, in particular, connected to better emotional well-being.

Keywords: Finland, mental health, natural environment, physical activity, sleep, well-being

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INTRODUCTION

Being exposed to nature, whether it be viewing pictures of natural landscapes or physical activity (PA) in the wild, has been found to have numerous health benefits. Previous epidemiological studies have found positive correlations between neighbourhood greenery and long term health indicators such as morbidity and longevity (Maas et al., 2009; Takano, Nakamura, & Watanabe, 2002). Experimental studies have focused on the short term positive effects of being exposed to green environments, such as changes in mood and physiological stress measures (see for example, Hartig, Evans, Jamner, Davis, & Gärling, 2003; Lee, Park, Tsunetsugu, Kagawa, & Miyazaki, 2009; Pretty, Peacock, Sellens, & Griffin, 2005). These benefits have been generally explained by involuntary attention recovery (Attention Restoration Theory, ART; Kaplan, 1995) and stress reduction on psychological and physiological levels (Ulrich, 1983; Ulrich et al., 1991; see Beute & de Kort, 2014, for a recent review).

Epidemiological studies have explored the correlation between green space indicators and improved well-being. The relationship has been established for a variety of measures of neighbourhood greenery, such as proximity, perceived quality, and the extent of the greenery (de Jong, Albin, Skärbäck, Grahn, & Björk, 2012; Stigsdotter et al., 2010; van Dillen, de Vries, Groenewegen, & Spreeuwenberg, 2012; Van Herzele & de Vries, 2012; Ward Thompson & Aspinall, 2011). Plausible mechanisms behind this relation include increased levels of PA (Mytton, Townsend, Rutter, & Foster, 2012), reduced stress, and social cohesion (de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013). Interestingly, a recent epidemiological study found that green exercise, but not the total amount of PA, mediated the connection between green space proximity and well-being (de Vries et al., 2013). By encouraging the above-mentioned healthy behaviour particularly in deprived populations, exposure to green space has been found to balance socioeconomic health inequalities (Mitchell & Popham, 2008; Ward Thompson & Aspinall, 2011).

The strong positive connection between PA and general and mental health has been widely accepted in previous research (Fox, 1999; Penedo & Dahn, 2005; Stephens, 1988). Whether exercising in nature, as opposed to other environments, provides added value to these beneficial effects has been the primary interest in many recent experimental studies. A meta-analysis by Bowler, Buyung-Ali, Knight, and Pullin (2010) outlined that exercising in a natural environment, rather than in built environments indoors or outdoors, reduces negative emotions and improves attention, while physical measures (blood pressure and cortisol concentration) had not shown systematic differences in the studies they reviewed. More specifically, the improvements in mood and self-esteem are experienced within five minutes of exposure

(Barton & Pretty, 2010). A systematic review by Thompson Coon et al. (2011) summarised that the benefits following exercise outdoors, compared with similar activities indoors, include increased energy and feelings of revitalisation, as well as decreases in tension, confusion, anger, and depression.

The following sections provide empirical evidence showing the potential effects of exposure to nature on stress and attention restoration, and the consequent implications on well-being and health. We conclude the introduction by presenting the outline and hypothesis of the present study.

Exposure to Nature and Mental Well-Being

Maas et al. (2009) found an inverse relationship between living less than one kilometre away from green space, and depression and anxiety disorders. There is also evidence that the proportion of greenery in the neighbourhood is connected to increased happiness (Van Herzele & de Vries, 2012), reduced mental distress (White, Alcock, Wheeler, & Depledge, 2013), and reduced stress on subjective and objective levels (Ward Thompson et al., 2012). Similarly, the quantity of green areas, as well as the quantity and quality of streetscape greenery, has been related to better mental health (van Dillen et al., 2012). Being active outdoors has been associated with enhanced mental well-being: the elderly showed fewer depressive symptoms the more time they spent outdoors and being physically active (Kerr et al., 2012), while a study in Scotland estimated that each additional weekly use of natural environment lowers the risk of poor mental health by 6 per cent (Mitchell, 2013). Similarly, a meta-analysis by Barton and Pretty (2010) found that those with mental illnesses benefitted systematically from exposure to nature more than others. On the other hand, in a population-based survey study, a positive measure of mental well-being exhibited a stronger positive connection to the use of non-natural environments than to nature (Mitchell, 2013).

Exposure to Nature and General Health

Good health has been associated with proximity to the nearest green space (Stigsdotter et al., 2010) and the proportion of greenery in the surrounding environment (Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006). However, the latter association has recently been questioned (de Jong et al., 2012; Van Herzele & de Vries, 2012). Interestingly, although de Jong et al. (2012) did not find a significant relationship between objective measures of neighbourhood greenery (via GIS) and perceived health, health correlated positively with perceived greenery. The latter result was also weakly supported by a study by Ward Thompson and Aspinall (2011). Besides quantity, better observed quality of the green areas and streets of the neighbourhood have also shown a relation to higher perceived general health (Van

Dillen et al., 2012). On an epidemiological level, living close to green elements has been connected to longevity (Takano et al., 2002) and decreased mortality rates (Mitchell & Popham, 2008).

Exposure to Nature and Sleep Quality

An epidemiological study in Australia found that people who live close to less green areas are more likely to sleep fewer hours per night (Astell-Burt, Feng, & Kolt, 2013). Apart from this study, the topic has received little research attention, although it has high relevance to public health. In Finland, for example, frequent insomnia-related symptoms are prevalent in 10 per cent of men and 14 per cent of women (Lallukka et al., 2012). Nocturnal awakening has been related to decreased quality of life (Väätäinen et al., 2013). Being in nature is likely to involve exposure to natural light and physical exercise, both of which have been found to have independent associations with sleep quality (Driver & Taylor, 2000). Similarly, a study on the elderly indicated that nocturnal sleep quality is associated with being active during the day as well as exposure to naturalistic light (Hood, Bruck, & Kennedy, 2004). The evidence on the health effects of light exposure on sleep is currently more extensive than the evidence regarding exposure to nature and sleep (Beute & de Kort, 2014). As exposure to nature and to daylight often coincides, their associated health benefits are likely to overlap (Beute & de Kort, 2014).

The Present Study

In line with the above studies, we hypothesise that the well-being benefits of PA differ between activities that occur in nature, indoors, and in built outdoor environments. We assume that attention and stress restoration, shown in previous experimental and epidemiological studies, produces long-term health and well-being benefits in an everyday context over repeated contacts with nature. Two of our outcomes, emotional well-being and perceived general health, have already been widely studied, whereas the third, sleep quality, has not been previously explored in this context.

MATERIALS AND METHODS

Data Collection

Our data were collected in two rounds (with a random sample of 4,000 people per round) in the winter and spring of 2009. Thus, the natural environments on which the responses are based include green, aquatic ("blue"), and snow-covered ("white") nature areas. The survey was part of the nationwide Outdoor Recreation Demand Inventory (LVVI2), conducted by the Finnish

Forest Research Institute, and it consisted of six survey rounds altogether with partly varying themes. In the first two survey rounds, analysed in this study, 3,060 Finnish respondents (response rate 38%), aged 15–74 years, completed and returned the questionnaire. When they were initially contacted, a letter was sent to each respondent with a link to an online questionnaire, personal username and password, along with a brochure about the study in general. The second reminder (of three), in addition, included a paper copy of the questionnaire.

The respondents represented the original sample fairly well although women were overrepresented relative to men by 3.4 percentage points, and the younger age groups were underrepresented (15- to 24-year-olds by 4.9 percentage points and 25- to 44-year-olds by 3.1 percentage points) relative to the older age groups (45- to 64-year-olds overrepresented by 5.1 percentage points and 65- to 75-year-olds by 2.9 percentage points; original figures from Virtanen, Nyberg, Salonen, Neuvonen, & Sievänen, 2011). To inspect the validity of the LVVI2 survey series, a phone survey for a random sample of the non-respondents in the final survey round (n = 301) was conducted (Virtanen et al., 2011).

Participation in the survey was voluntary and based on informed consent; it did not expose the respondents to any harm, and the respondents were given all the necessary information regarding the study. Therefore, according to the Finnish Advisory Board on Research Integrity, an ethical review of the study was not required (http://www.tenk.fi/en/).

Measures

Outcomes. *Emotional well-being* was measured by five statements that comprise the Emotional Well-Being subscale in the RAND 36-item health survey 1.0 (Hays, Sherbourne, & Mazel, 1993; validated in Finland by Aalto, Aro, & Teperi, 1999; see Appendix 1, in the Supplementary Data, for the complete items of the scale). The items were measured on a 6-point Likert scale ranging from "All of the time" (1) to "Not at all" (6). In the analyses, if necessary, the outcomes were inverted so that higher values indicated better well-being. Perceived *general health* was investigated with a single question phrased, "In general, would you say your health is": with the options "good" (1), "fairly good" (2), "average" (3), "fairly poor" (4) and "poor" (5). Assessing perceived general health by a single item is a widely acknowledged practice in health research (Idler & Benyamini, 1997; Miilunpalo, Vuori, Oja, Pasanen, & Urponen, 1997). Likewise, *sleep quality* was investigated with a single question asking how often in the past four weeks the respondents had experienced sleep problems or poor sleep quality, with the same options as the items of the emotional well-being scale. A comprehensive and widely used sleep assessment scale, the Pittsburgh Sleep Quality Index (PSQI; Buysse,

Reynolds, Monk, Berman, & Kupfer, 1989), also assesses sleep quality in the past four weeks by a single item, and the item has shown the highest correlation with the overall score of the same index (Carpenter & Andrykowski, 1998).

Physical Activity. The PA measures were quantified by merging two variables, one estimating the weekly frequency of PA and the other recording the locations where the PA takes place. Regarding the locations of PA, the respondents were instructed to estimate the proportions of their spare time PA that take place in seven types of environment (with examples in brackets). These environments were grouped into three categories for the purposes of this study. Indoor sports settings (such as indoor sports hall, gym, or swimming pool) and indoors at home (such as heavy housework or home gymnastics) were classified in the group *indoors*. *Outdoors in a built setting* (such as streets, cycle lanes, or sports fields) formed its own category. Outdoors around home (such as gardening, clearing the snow, or ball games) was excluded from the analysis because it could refer to both natural and built settings. The final category, *nature*, included the natural environment near home (such as nearby forests or urban parks), the natural environment around one's second home, and the natural environment elsewhere. Regarding the weekly frequency of PA, the respondents were instructed to only consider active bouts that lasted at least 20 minutes (a common measure in previous Finnish population studies; for example, Peltonen et al., 2008), during which they breathed more heavily and broke into a sweat (excluding walking, cycling, running, etc. as part of their normal daily activities).

Finally, the measures in the analyses were obtained by multiplying the weekly frequency of PA by the proportions taking place in each type of setting. For example, if the respondent claimed to exercise twice a week, 50 per cent of the time indoors and 50 per cent in nature, the new variables PA indoors and PA in nature would both be equal to $2 \times 0.5 = 1$.

An estimate of how active the respondent had been in the past four weeks, indicating the intensity of PA, was derived from a variable *general activity*. The instrument, adapted from the widely used scale "Self-reported Physical Activity", developed by Saltin and Grimby (1968), has been found to have stronger connections to mental health than an objective measure of physical fitness (Lindwall, Ljung, Hadžibajramović, & Jonsdottir, 2012). The measure consists of four response categories that depict the respondent's activity and exertion level (see Appendix 1, Supplementary Data).

Covariates. The first demographic covariate was *gender*. Within the Finnish population, gender has not shown a relationship to perceived health (Kallio, 2006) or emotional well-being (Aalto et al., 1999). Conversely, sleep problems are more common in females (Lallukka et al., 2012; Ohayon &

Partinen, 2002), with the exception of sleep apnoea, which is more prevalent in men (Kronholm et al., 2009). The second demographic covariate, *age*, has been found to correlate negatively with perceived health (in Finland, Aalto et al., 1999) and sleep quality (Driver & Taylor, 2000) but not with mental health (Aalto et al., 1999). There is additional evidence that different age groups respond differently to exposure to nature (Barton & Pretty, 2010; Maas et al., 2009). Low levels of the third covariate, monthly household *income*, have been associated with lower emotional well-being (Lahelma, Laaksonen, Martikainen, Rahkonen, & Sarlio-Lähteenkorva, 2006) and sleeping fewer hours per night (Lallukka et al., 2012) in Finland. In general, subjective socioeconomic status and perceived health correlate positively (Kallio, 2006). Epidemiological studies have found fewer income-related health inequalities in the greener neighbourhoods (Maas et al., 2009; Mitchell & Popham, 2008). The fourth demographic covariate, *household size*, was added to control for the bias it could cause in income.

In addition, we tested for alternative explanations for the well-being measures, as suggested by Spector and Brannick (2011). Recent unusual events might affect well-being; this was considered by asking the respondents whether they had been going through an *exceptional situation in life* in the previous four weeks, and if the phase had been easier or more difficult than usual. Permanent or long term illnesses or disabilities may affect physical and mental functioning, so we enquired whether the respondents had long term *disabilities* that impede their physical activities outdoors. To consider any other less permanent disadvantages in life the respondents may experience, such as lack of time or facilities, we asked whether they had been able to exercise outdoors as much as they had wished (*constraints*) in the previous 12 months. Finally, *season* (winter or spring) affects natural light exposure which may cause fluctuations in sleep quality (Hood et al., 2004), impact emotional well-being (Graw, Recker, Sand, Kräuchi, & Wirz-Justice, 1999), and alter exercise routines (Tucker & Gilliland, 2007).

Statistical Analysis

There were in total 28 (0.9%) respondents that had a long term illness or disability that prevented them from going outdoors, and they were excluded from the analyses. In addition, multivariate outliers, evaluated by Mahalanobis distances, were detected and excluded from the data iteratively following the guidelines of Tabachnick and Fidell (2007). Only the most distinguishable extreme cases were excluded each time, and after each exclusion, the Mahalanobis distances were re-calculated and re-inspected. The exclusion of outliers was complete when the largest Mahalanobis value was close to the selected critical value (based on the χ^2 distribution with df = "number of variables" – 1) and the normal probability plot ceased to have a

distinguishable tail at the larger end. After the exclusion, the correlations were re-examined and compared to the pre-filtered data.

For the main analyses, all variables were incorporated into structural regression models using Mplus version 7. The main reason for choosing a structural model was its ability to control for the covariance between independent variables as well as the health measures. Emotional well-being was specified as a latent factor with five ordinal indicators, and general health and sleep quality were treated as latent single indicator factors. We used the recommended approach in the model building where the models of interest are tested immediately without a preceding measurement model for the latent constructs (Hayduk & Glaser, 2000). As all observed outcome variables were ordinal, a normal transformation was performed and a diagonally weighted least squares (WLSMV) estimator was used (Muthén & Muthén, 1998–2012).

Independent variables were added in the constructed models in four main steps that were specified following the suggestions of Spector and Brannick (2011). The authors recommend first examining the relationships that are theoretically expected, after which other feasible alternatives should be tested. The *first step* consisted of PA indoors, in built outdoor environments, and in nature regressing on emotional well-being, general health, and sleep quality. In the *second step*, a measure of the intensity of activity was added. In the *third step*, we added the covariates. If a covariate was not significant in most analyses, either the insignificant paths or the covariate itself was deleted from the following models. The fourth and the *final step* included alternative explanations for the health outcomes.

The SEM models were evaluated with the χ^2 test and the related fit indices available in the WLSMV estimation. The Bentler comparative fit index (CFI) measures how far the specified model is from the baseline model with no connections (Raykov & Marcoulides, 2011), and the general guidelines are 0.95 for close fit, whereas less than 0.90 is considered unacceptable (Hu & Bentler, 1999; Yu, 2002). As for the root mean-square error of approximation (RMSEA), the maximum acceptable value varies between 0.05 and 0.08 (Browne & Cudeck, 1992; Hu & Bentler, 1999). In addition, we compared the observed outcome values with the probabilities that their model-estimated value is correct.

RESULTS

Univariate and Bivariate Distributions

All outcomes had a skewed distribution, with the average responses approaching higher rather than lower values of well-being (see Table 1 for all observed distributions). The emotional well-being scale, for which comparative population figures were readily available, was distributed with the same

TABLE 1
Distributions of the Observed Variables (n = 2,070)

Variable	*Scale or range*	*Mean* (SD) *or %*
Emotional well-being (Cronbach's $\alpha = 0.846$)	0–100 (summary score)	77.6 (15.4)
Perceived general health	Good (1)–Poor (5)	2.0 (0.93)
Poor sleep quality or sleep problems	All of the time (1)–Not at all (6)	4.8 (1.16)
Gender (%)	Male	44.4
	Female	55.6
Age	15–74 years	45.2 (14.8)
Household size	1–8 people	2.5 (1.2)
Monthly household income[a] (%)	€1,000 or less	5.9
	€1,001–3,000	32.6
	€3,001–5,000	31.7
	€5,001–7,000	19.2
	€7,001–9,000	6.1
	More than €9,000	4.4
Long term disability (%)	None	82.9
	Yes, but can still exercise outdoors	17.1
Exceptional situation in life in the past 4 weeks (%)	More stressful than usual	27.3
	Not exceptional	64.6
	Easier than usual	8.1
Constraints on outdoor exercise in the past 12 months (%)	None	55.6
	Some	44.4
General activity in the past four weeks (%)	Inactive	14.2
	Moderate activity	53.0
	Vigorous activity	30.9
	Competitive sports	1.9
Weekly frequency of PA by location (max 5 times)	Indoors	0.7 (0.8)
	Outdoors (built)	0.5 (0.7)
	In nature	0.9 (0.9)
Season	Winter	51.9
	Spring	48.1

[a] shortened scale, in the analysis we used 11 categories.

median (80) as the national norms, although in our sample, mean value was slightly greater (78 versus 74) and standard deviation smaller (15 versus 20) than the available population values (Aalto et al., 1999).

Regarding bivariate distributions, all independent variables had a significant correlation coefficient ($p < .05$) with at least one of the three well-being measures (Table 2; see Appendix 2a for correlations within the independent variables and Appendix 2b, in the Supplementary Data, for correlations within the outcomes). Some of the significant correlations were small in magnitude which is common in many research fields, including applied

TABLE 2
Correlation Coefficients (Spearman if One or Both of the Variable Pair are Ordinal, Pearson in Italics) between the Observed Independent and Outcome Variables (n = 2,070)

	Emotional well-being (RAND-36 score)	*Perceived general health*	*Sleep quality*
PA indoors	*0.05**	0.25***	0.04
PA outdoors (built)	*0.07***	0.20***	0.02
PA in nature	*0.17****	0.15***	0.08***
General activity	0.17***	0.40***	0.11***
Gender[a]	–0.02	0.08***	0.00
Age	*0.20****	–0.20***	0.05*
Household size	*–0.03*	0.09***	0.03
Income	0.12***	0.11***	0.07**
Exceptional situation in life	0.36***	0.11***	0.19***
Disability	–0.07**	–0.36***	–0.10***
Constraints	–0.23***	–0.23***	–0.14***
Season	–0.02	0.01	0.06*

* $p < .05$; ** $p < .01$; *** $p < .001$.
[a] 0 = male, 1 = female.

psychology (Møller & Jennions, 2002; Tabachnick & Fidell, 2007). The well-being effects of contact with nature are generally smaller than the well-being effects of socioeconomic or behavioural characteristics (Hartig, Mitchell, de Vries, & Frumkin, 2014).

In all, 2,122 subjects (70% of the 3,032 that were able to go outdoors) had a valid response to the 19 questions included in the analysis. The final sample consisted of 2,070 cases where 52 respondents (2.5% of valid cases) had been excluded due to multivariate non-normality, evaluated by Mahalanobis distances (with $p < .001$, the critical value is $\chi^2(18) = 43.8$). Although these cases were excluded, the univariate distributions and the bivariate correlations of the original and the cleaned data did not differ substantially. Altogether, the sample in this study consists of 26 per cent of the 8,000 individuals to whom the survey was sent.

Structural Regression Models

In the first step of the analysis (see Appendix 3a, Supplementary Data, for an overview), PA in nature exhibited a positive connection to emotional well-being (B = 0.21, standard error (SE) = 0.03, $p < .001$; Table 3), perceived general health (B = 0.14, SE = 0.03, $p < .01$), and sleep quality (B = 0.09, SE = 0.02, $p < .01$). PA in built outdoor settings was positively associated with emotional well-being (B = 0.10, SE = 0.04, $p < .01$) and general health

TABLE 3
Structural Regression Models (n = 2,070). Significance Levels Indicated by Italics if $p < .05$, Bold if $p < .01$, and Bold Italics if $p < .001$

	Model 1			*Model 2*			*Model 3*			*Model 4*		
	Emotional well-being	*General health*	*Sleep quality*	*Emotional well-being*	*General health*	*Sleep quality*	*Emotional well-being*	*General health*	*Sleep quality*	*Emotional well-being*	*General health*	*Sleep quality*
PA indoors	0.03	***0.32***	0.05	*–0.09*	**0.10**	–0.01	–0.02	0.01	0.00	–0.05	0.02	–0.01
PA outdoors (built)	**0.10**	***0.22***	0.03	0.05	***0.14***	0.00	0.05	***0.15***	0.00	0.01	*0.09*	–0.02
PA in nature	***0.21***	***0.14***	***0.09***	***0.16***	0.04	*0.06*	***0.13***	**0.09**	*0.05*	**0.08**	*0.06*	0.02
General activity				***0.30***	***0.61***	***0.17***	***0.29***	***0.63***	***0.15***	***0.25***	***0.58***	**0.11**
Gender[b]							[a]	***0.22***	[a]	[a]	***0.27***	[a]
Age							***0.02***	***–0.02***	*0.00*	***0.01***	***–0.02***	0.00
Income							***0.04***	***0.04***	*0.03*	***0.05***	**0.03**	*0.02*
Exceptional situation in life										***0.66***	***0.22***	***0.32***
Disability										***–0.20***	***–0.95***	***–0.29***
Constraints										***–0.34***	***–0.42***	***–0.19***
Season[c]										–0.05	0.03	**0.14**
R^2 (%)	4.1	10.5	0.9	7.1	20.3	1.8	12.4	25.5	2.4	26.1	37.6	7.9
χ^2 Value	405			388			463			518		
χ^2 *df*	25			29			43			59		
χ^2 *p*	<.001			<.001			<.001			<.001		
CFI	0.97			0.97			0.97			0.96		
RMSEA	0.09			0.08			0.07			0.06		

[a] Path deleted; [b] 0 = male, 1 = female; [c] 0 = winter, 1 = spring.

(B = 0.22, SE = 0.04, p < .01). The only outcome that PA indoors was significantly (and positively) related to was general health (B = 0.32, SE = 0.03, p < .01).

In the second estimated model (Appendix 3b, Supplementary Data), the added variable general activity was significantly and strongly related to all outcomes, and it reduced the coefficient estimates of the PA variables compared with the previous model. Associations that remained significant were those between PA in nature and emotional well-being (B = 0.16, SE = 0.03, p < .01) and sleep quality (B = 0.06, SE = 0.03, p = .02), PA outdoors (built) and general health (B = 0.14, SE = 0.04, p < .01), and PA indoors and general health (B = 0.10, SE = 0.03, p < .01). Unexpectedly, a new significant negative relationship appeared between PA indoors and emotional well-being (B = –0.09, SE = 0.04, p = .02).

The third estimated model (Appendix 3c, Supplementary Data), in which demographic covariates were added, required adjustment. Household size showed no significant connections to any outcomes and, therefore, it was removed from the subsequent analyses. In line with bivariate correlations (Table 2), gender was only related to perceived general health, and removing its connections with the other two outcomes improved the model fit. Higher income level was significantly and positively associated with each of the three outcomes. Perceived health decreased and emotional well-being and sleep quality increased with age. By adding these covariates, all connections between PA indoors and the outcomes appeared non-significant, whereas PA in nature continued to show a positive association with emotional well-being (B = 0.13, SE = 0.03, p < .01), general health (B = 0.09, SE = 0.03, p < .01), and sleep quality (B = 0.05, SE = 0.03, p = .04). The frequency of PA in built outdoor settings was, additionally, positively connected to general health (B = 0.15, SE = 0.04, p < .01).

Apart from season, all new regressor variables added in model 4 (Figure 1) were strongly and significantly related to the health outcomes. Those who had responded to the survey in spring reported slightly better sleep quality than the ones who had responded in winter. Having a longer-term disability or other constraint on exercising outdoors was negatively related to emotional well-being, general health, and sleep quality. Going through an exceptionally positive phase in life had a positive relationship with these outcomes. There was some overlap with the independent variables introduced and the PA measures, as the coefficients of the PA measures reduced and became less significant. PA in built outdoor settings and in nature were only weakly related to general health ($B_{outdoors(built)}$ = 0.09, SE = 0.04, p = .02; $B_{in\ nature}$ = 0.06, SE = 0.03, p = .04), and the weak positive connection that PA in nature previously shown to sleep quality was no longer apparent (B = 0.02, SE = 0.03, p = .38). Emotional well-being and PA in nature continued to be significantly related, although the estimated coefficient was somewhat reduced (B = 0.08, SE = 0.03, p < .01).

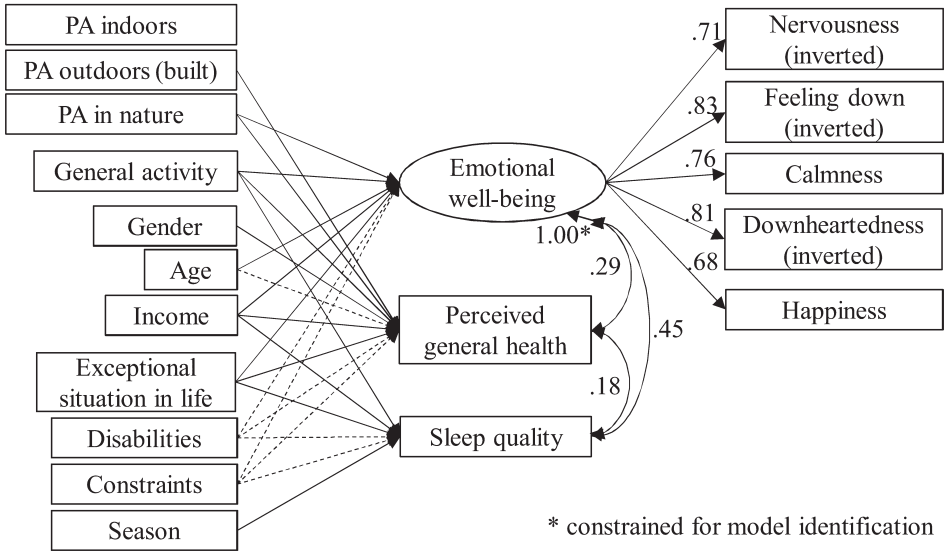

FIGURE 1. Diagram of model 4. $\chi^2 = 518$, $df = 59$, $p < .0001$, CFI = 0.96, RMSEA = 0.06. Only significant ($p < .05$) connections are shown (arrows). The dashed arrows represent negative connections. The regression coefficients between independent and dependent variables are provided in Table 3.

Another difference from the previous model was that age and sleep quality were no longer significantly connected. The final model explained 26 per cent of the variation in emotional well-being, 38 per cent of the variation in perceived general health, and 8 per cent of the variation in sleep quality.

The model fit improved and the variances explained increased in each step (Table 3). Besides the χ^2 test, which rejected each model, the fit indices showed acceptable fit in all models (except the first model where the RMSEA was 0.09). In the final model, almost all the higher scores of the emotional well-being indicators were correctly estimated, whereas the low scores were not predicted so well. The values of general health were well estimated throughout the scale. Regarding sleep quality, the high values were estimated better than low values, although many values throughout the scale were incorrectly estimated.

DISCUSSION AND CONCLUSIONS

Evidence on the Relationship between PA in Different Environments and Perceived Health

Overall, repeated PA in nature, in comparison with built locations, seems to provide added benefits for subjective health. PA in nature and *emotional*

well-being showed a significant connection in every phase of the analysis, whereas PA in other locations did not. The connection was evident even after controlling for general activity level and unusual life events. This result is in line with previous studies where green exercise has been related to better mental well-being in the long term (in the past four weeks; de Vries et al., 2013) and short term (immediately after exposure; Barton & Pretty, 2010; Bowler et al., 2010; Thompson Coon et al., 2011). Another result supporting previous evidence (de Vries et al., 2013) was the positive connection between *general health* and PA outdoors, although this was not specific to natural environments. The result is, furthermore, in agreement with the epidemiological studies that have shown the connection between green space proximity and general health (de Jong et al., 2012; Maas et al., 2006; Stigsdotter et al., 2010; Ward Thompson & Aspinall, 2011). Finally, engaging more frequently in PA in nature and having better *sleep quality* were weakly connected in all structural analyses except the final model. These conflicting results indicate that PA in nature and sleep quality are related, but the associated mechanism might be dependent on other factors.

Sleep quality was the least adequately explained outcome in our models, with the highest R^2 being only 8 per cent. Even though we found factors that were connected to sleep quality, at this point the results are suggestive. We suspect that either the selected regressors or the single-item measurement was insufficient to capture all relevant aspects of sleep quality. Most sleep quality indicators in sleep research comprise several items on different aspects of sleep quality (see Lomeli et al., 2008, for a review). In applied sleep research, however, single items have been found useful as they minimise response burden and allow individuals to determine themselves which aspects of sleep quality are relevant (Cappelleri et al., 2009). A single item can be indicative of more comprehensive sleep measures (Carpenter & Andrykowski, 1998) but, based on this study, we cannot infer whether the low variance explained was due to the model itself or the selected measure.

The situational factors showed both unexpected and expected dependencies. Contrary to the general preconceptions, season (winter or spring) barely correlated with the well-being outcomes or with the frequency measures of PA. Indeed, a reliability analysis of the LVVI2 survey series (of which the data in this study were a part) has shown that, in Finland, there are no differences between seasons in the most popular forms of PA such as walking for pleasure or fitness, Nordic walking, and jogging (Korpela, Borodulin, Neuvonen, Paronen, & Tyrväinen, 2014). Then again, as could be expected, unusual life events and constraints and disabilities that partly (but not totally) constricted the respondents' outdoor visits were negatively correlated with each PA measure, as well as each outcome. By adding them in the model, most relationships between PA and health measures were suppressed as their coefficients decreased and significance levels increased. It seems that having a long

term disability or other hindrance to exercise outdoors, or going through a difficult phase in life, does not necessarily eliminate the benefits of exercising, albeit they do reduce the effects of these relationships. Nonetheless, the principal finding of this study was that the relationships between frequent PA in nature and better emotional well-being and perceived health remained significant even though these wider situational factors were controlled for.

The demographic covariates, with the exception of gender, behaved mainly as expected based on previous research. Higher income was positively related to all three outcomes, and perceived health decreased with age. Unexpectedly, age was positively associated with mental well-being, and its relationship to sleep quality was also weakly positive (unlike the suggestion of Driver & Taylor, 2000). We had expected women to have more sleep problems but no such connection was found. Instead, women rated their health higher than men.

A weakness in all of our analyses was that the models failed to explain low values of the two main outcomes. Those whose emotional well-being was low, as well as those who had been experiencing poor sleep quality most of the time, were poorly estimated in all our analyses. The models thus explained well-being rather than "ill-being". In this sense, the results differ from the study by Mitchell (2013) where exercising in nature was more closely related to the risk of poor mental health than to the positive measure of well-being.

Limitations of the study include the use of cross-sectional data that do not permit the assessment of causalities. In addition, self-report measures have been widely acknowledged to suffer from social desirability and memory bias effects (Cooper, 1998). The theme of the survey was outdoor recreation, and we acknowledge the risk of self-selection. People who enjoy recreational activities outdoors may be more inclined to respond to a survey on this theme, even though the theme covered activities in all types of outdoor environments, including both natural and built environments. However, the validity study (see the section on data collection) of the related survey concluded that the respondents and non-respondents did not differ substantially from each other with regard to their participation in outdoor recreation (Virtanen et al., 2011). As the response rates and demographics between the sample in this study and the sample for which the validity analysis was conducted were similar (Virtanen et al., 2011), we have a strong basis to believe that this validity analysis also applies to the data we analysed. Therefore, we consider the potential effect of selection bias on the validity of our results to be only minor.

It is, in addition, possible that some of our findings are culturally affected. Finns and other Nordic peoples are more active in outdoor recreation compared with citizens in other parts of Europe (Bell, Tyrväinen, Sievänen, Pröbstl, & Simpson, 2007), and may therefore perceive natural environments more positively than those who are less familiar with nature. Then again, with Finnish people living on average within 700 metres distance from a forest

(Sievänen & Neuvonen, 2011), the results are not likely to have been affected by inequalities in access to natural facilities.

Finally, there are some alternative explanations for the results that were not considered in the analyses. First, no information on the nearby greenery of the respondents' living environments was available. Nearby greenery may, for instance, encourage engagement in physical activities (Mytton et al., 2012) and impact sleep quality through light pollution and noise. Second, we do not know whether the average duration of exercise indoors, outdoors in built settings, and in nature varies. If visits to the natural environments tend to last longer, the increased amount of physical activity and exposure to natural light could, at least partly, explain the strong relationship between exercise in nature and well-being. Third, the broad categorisation into indoor, built outdoor, and natural environments ignored the qualitative differences within the environments in the same category. Different types of natural environments may induce different restorative effects (Korpela, Ylén, Tyrväinen, & Silvennoinen, 2010; Tyrväinen et al., 2014) and therefore, the detected associations may not apply to all natural environments.

Validity of the Methods and Results

Most of our measures are standard in research practice in health sciences and gave us no reason to suspect their validity or reliability. Measures that necessitate some discussion are the estimation of the amount and intensity of PA. Compared with controlled experiments, a self-report questionnaire inevitably provides less accurate measures of PA. Nonetheless, estimating one's activities in weekly intervals was considered sufficiently easy for the respondents to estimate. Another problem with the measure was that it assumed that PA in different types of settings is something one does in a generally consistent way from week to week, which might not be the case and, consequently, may bias the estimate. Our measure of the general intensity of PA, however, has previously been shown to be a stronger connection to mental health than an objective measure of aerobic fitness (Lindwall et al., 2012). Nevertheless, we consider our estimates of frequency and intensity of PA capable of at least clearly distinguishing the most active from those who exercise only occasionally.

Based on the RMSEA and the CFI, our models 2–4 fit the data well. The fact that the CFIs somewhat worsened and the RMSEAs improved as new independent variables were added is a common phenomenon (Kenny & McCoach, 2003). The χ^2 values, on the contrary, were far from the ideal. We deduced three reasons for the failure of this test. First, the χ^2 test is known to be too sensitive when sample sizes are large ($N > 300$; Kline, 2011). The RMSEA, a similar measure that is less sensitive to sample size, supported most of the tested models. Second, the models better explained positive rather than

negative emotional well-being and sleep quality, resulting in some large residuals that evidently influenced the χ^2 value. Third, the largest residuals between the observed and estimated correlations appeared between the items of the RAND-36. Had we constrained some of their residual variances, the fit could have been artificially improved, but we found it theoretically unjustifiable.

Conclusions

This study provides a new type of survey evidence supporting the theories on health-enhancing effects of contact with nature by suggesting that repeated exercise in nature is related to improved long term well-being more explicitly than repeated exercise in built environments indoors or outdoors. Good emotional well-being, in particular, seems to be evidently associated with more frequent, active visits to natural environments. Moreover, perceived general health appears to be connected to PA both in nature and in built outdoor settings. The evidence on sleep quality, on the other hand, was weaker in this study. More research is needed to better understand the connection between exposure to nature and sleep. Whether this relationship is, for example, mediated by improved psychological well-being or neighbourhood qualities is worthy of further examination.

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CONFLICT OF INTEREST

None.

REFERENCES

Aalto, A., Aro, A.R., & Teperi, J. (1999). *RAND-36 terveyteen liittyvän elämänlaadun mittarina: mittarin luotettavuus ja suomalaiset väestöarvot* [RAND-36 as a measure of health-related quality of life: Reliability, construct validity and reference values in the Finnish general population]. Helsinki: Stakes.

Astell-Burt, T., Feng, X., & Kolt, G.S. (2013). Does access to neighbourhood green space promote a healthy duration of sleep? Novel findings from a cross-sectional study of 259 319 Australians. *BMJ Open*, *3*(8). doi:10.1136/bmjopen-2013-003094

Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science & Technology*, *44*(10), 3947–3955. doi:10.1021/es903183r

Bell, S., Tyrväinen, L., Sievänen, T., Pröbstl, U., & Simpson, M. (2007). Outdoor recreation and nature tourism: A European perspective. *Living Reviews in Landscape Research*, *1*(2), 1–46.

Beute, F., & de Kort, Y.A.W. (2014). Salutogenic effects of the environment: Review of health protective effects of nature and daylight. *Applied Psychology: Health and Well-Being*, *6*(1), 67–95. doi:10.1111/aphw.12019

Bowler, D.E., Buyung-Ali, L., 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*, 456–465.

Browne, M.W., & Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociological Methods & Research*, *21*(2), 230–258.

Buysse, D.J., Reynolds III, C.F., Monk, T.H., Berman, S.R., & Kupfer, D.J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*(2), 193–213. doi:10.1016/0165-1781(89)90047-4

Cappelleri, J., Bushmakin, A., McDermott, A., Sadosky, A., Petrie, C., & Martin, S. (2009). Psychometric properties of a single-item scale to assess sleep quality among individuals with fibromyalgia. *Health and Quality of Life Outcomes*, *7*(1), 54.

Carpenter, J.S., & Andrykowski, M.A. (1998). Psychometric evaluation of the Pittsburgh Sleep Quality Index. *Journal of Psychosomatic Research*, *45*(1), 5–13. doi:10.1016/S0022-3999(97)00298-5

Cooper, C. (1998). *Individual differences*. London: Arnold.

De Jong, K., Albin, M., Skärbäck, E., Grahn, P., & Björk, J. (2012). Perceived green qualities were associated with neighborhood satisfaction, physical activity, and general health: Results from a cross-sectional study in suburban and rural Scania, southern Sweden. *Health & Place*, *18*(6), 1374–1380. doi:10.1016/j.healthplace.2012.07.001

De Vries, S., van Dillen, S.M.E., Groenewegen, P.P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine*, *94*(0), 26–33. doi:10.1016/j.socscimed.2013.06.030

Driver, H.S., & Taylor, S.R. (2000). Exercise and sleep. *Sleep Medicine Reviews*, *4*(4), 387–402. doi:10.1053/smrv.2000.0110

Fox, K.R. (1999). The influence of physical activity on mental well-being. *Public Health Nutrition*, *2*(3a), 411–418.

Graw, P., Recker, S., Sand, L., Kräuchi, K., & Wirz-Justice, A. (1999). Winter and summer outdoor light exposure in women with and without seasonal affective disorder. *Journal of Affective Disorders*, *56*(2–3), 163–169. doi:10.1016/S0165-0327(99)00037-3

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:10.1016/S0272-4944(02)00109-3

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health*, *35*(1), 207–228. doi:10.1146/annurev-publhealth-032013-182443

Hayduk, L.A., & Glaser, D.N. (2000). Jiving the four-step, waltzing around factor analysis, and other serious fun. *Structural Equation Modeling: A Multidisciplinary Journal*, *7*(1), 1–35. doi:10.1207/S15328007SEM0701_01

Hays, R.D., Sherbourne, C.D., & Mazel, R.M. (1993). The RAND 36-item health survey 1.0. *Health Economics*, *2*(3), 217–227. doi:10.1002/hec.4730020305

Hood, B., Bruck, D., & Kennedy, G. (2004). Determinants of sleep quality in the healthy aged: The role of physical, psychological, circadian and naturalistic light variables. *Age and Ageing*, *33*(2), 159–165.

Hu, L., & Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55.

Idler, E.L., & Benyamini, Y. (1997). Self-rated health and mortality: A review of twenty-seven community studies. *Journal of Health and Social Behavior*, *38*(1), 21–37.

Kallio, J. (2006). Koettu terveys ja terveydellinen tasa-arvo kuudessa hyvinvointivaltiossa [Self-perceived health and health differences in six welfare states]. *Sosiaalilääketieteellinen Aikakauslehti—Journal of Social Medicine*, *43*(3), 218–230.

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

Kenny, D.A., & McCoach, D.B. (2003). Effect of the number of variables on measures of fit in structural equation modeling. *Structural Equation Modeling*, *10*(3), 333–351.

Kerr, J., Marshall, S., Godbole, S., Neukam, S., Crist, K., Wasilenko, K. et al. (2012). The relationship between outdoor activity and health in older adults using GPS. *International Journal of Environmental Research and Public Health*, *9*(12), 4615–4625.

Kline, R.B. (2011). *Principles and practice of structural equation modeling* (3rd edn.). New York: Guilford Press.

Korpela, K., Borodulin, K., Neuvonen, M., Paronen, O., & Tyrväinen, L. (2014). Analyzing the mediators between nature-based outdoor recreation and emotional well-being. *Journal of Environmental Psychology*, *37*, 1–7. doi:10.1016/j.jenvp.2013.11.003

Korpela, K.M., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2010). Favorite green, waterside and urban environments, restorative experiences and perceived health in Finland. *Health Promotion International*, *25*(2), 200–209. doi:10.1093/heapro/daq007

Kronholm, E., Sallinen, M., Suutama, T., Sulkava, R., Era, P., & Partonen, T. (2009). Self-reported sleep duration and cognitive functioning in the general population. *Journal of Sleep Research*, *18*(4), 436–446. doi:10.1111/j.1365-2869.2009.00765.x

Lahelma, E., Laaksonen, M., Martikainen, P., Rahkonen, O., & Sarlio-Lähteenkorva, S. (2006). Multiple measures of socioeconomic circumstances

and common mental disorders. *Social Science & Medicine*, *63*(5), 1383–1399. doi:10.1016/j.socscimed.2006.03.027

Lallukka, T., Sares-Jaske, L., Kronholm, E., Saaksjarvi, K., Lundqvist, A., Partonen, T. et al. (2012). Sociodemographic and socioeconomic differences in sleep duration and insomnia-related symptoms in Finnish adults. *BMC Public Health*, *12*(1), 565–586.

Lee, J., Park, B., Tsunetsugu, Y., Kagawa, T., & Miyazaki, Y. (2009). Restorative effects of viewing real forest landscapes, based on a comparison with urban landscapes. *Scandinavian Journal of Forest Research*, *24*(3), 227–234. doi:10.1080/02827580902903341

Lindwall, M., Ljung, T., Hadžibajramović, E., & Jonsdottir, I.H. (2012). Self-reported physical activity and aerobic fitness are differently related to mental health. *Mental Health and Physical Activity*, *5*(1), 28–34.

Lomeli, H.A., Perez-Olmos, I., Talero-Gutierrez, C., Moreno, C.B., Gonzalez-Reyes, R., Palacios, L. et al. (2008). Sleep evaluation scales and questionnaires: A review. *Actas Espanolas De Psiquiatria*, *36*(1), 50–59.

Maas, J., Verheij, R.A., de Vries, S., Spreeuwenberg, P., Schellevis, F.G., & Groenewegen, P.P. (2009). Morbidity is related to a green living environment. *Journal of Epidemiology and Community Health*, *63*(12), 967–973. doi:10.1136/jech.2008.079038

Maas, J., Verheij, R.A., Groenewegen, P.P., de Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: How strong is the relation? *Journal of Epidemiology and Community Health*, *60*(7), 587–592. doi:10.1136/jech.2005.043125

Miilunpalo, S., Vuori, I., Oja, P., Pasanen, M., & Urponen, H. (1997). Self-rated health status as a health measure: The predictive value of self-reported health status on the use of physician services and on mortality in the working-age population. *Journal of Clinical Epidemiology*, *50*(5), 517–528. doi:10.1016/S0895-4356(97)00045-0

Mitchell, R. (2013). Is physical activity in natural environments better for mental health than physical activity in other environments? *Social Science & Medicine*, *91*, 130–134. doi:10.1016/j.socscimed.2012.04.012

Mitchell, R., & Popham, F. (2008). Effect of exposure to natural environment on health inequalities: An observational population study. *The Lancet*, *372*(9650), 1655–1660. doi:10.1016/S0140-6736(08)61689-X

Møller, A., & Jennions, M.D. (2002). How much variance can be explained by ecologists and evolutionary biologists? *Oecologia*, *132*(4), 492–500.

Muthén, L.K., & Muthén, B.O. (1998–2012). *Mplus user's guide* (7th edn.). Los Angeles, CA: Muthén & Muthén.

Mytton, O.T., Townsend, N., Rutter, H., & Foster, C. (2012). Green space and physical activity: An observational study using Health Survey for England data. *Health & Place*, *18*(5), 1034–1041. doi:10.1016/j.healthplace.2012.06.003

Ohayon, M.M., & Partinen, M. (2002). Insomnia and global sleep dissatisfaction in Finland. *Journal of Sleep Research*, *11*(4), 339–346.

Peltonen, M., Harald, K., Männistö, S., Saarikoski, L., Lund, L., Sundvall, J. et al. (2008). *Kansallinen FINRISKI 2007-terveystutkimus: Tutkimuksen toteutus ja*

tulokset. taulukkoliite [The National FINRISKI 2007 Health Study: Procedure and results. Table appendix]. Kansanterveyslaitos.

Penedo, F.J., & Dahn, J.R. (2005). Exercise and well-being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, *18*(2), 189–193.

Pretty, J., Peacock, J., Sellens, M., & Griffin, M. (2005). The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research*, *15*(5), 319–337.

Raykov, T., & Marcoulides, G.A. (2011). *Introduction to psychometric theory*. New York: Routledge.

Saltin, B., & Grimby, G. (1968). Physiological analysis of middle-aged and old former athletes: Comparison with still active athletes of the same ages. *Circulation*, *38*(6), 1104–1115. doi:10.1161/01.CIR.38.6.1104

Sievänen, T., & Neuvonen, M. (2011). Luonnon virkistyskäytön kysyntä 2010 ja kysynnän muutos. [Outdoor recreation demand 2010 and changes in the demand]. In T. Sievänen & M. Neuvonen (Eds.), *Luonnon virkistyskäyttö 2010* [Outdoor recreation 2010]. Working Papers of the Finnish Forest Research Institute No. 212 (pp. 37–73). Vantaa: Metsäntutkimuslaitos.

Spector, P.E., & Brannick, M.T. (2011). Methodological urban legends: The misuse of statistical control variables. *Organizational Research Methods*, *14*(2), 287–305. doi:10.1177/1094428110369842

Stephens, T. (1988). Physical activity and mental health in the United States and Canada: Evidence from four population surveys. *Preventive Medicine*, *17*(1), 35–47. doi:10.1016/0091-7435(88)90070-9

Stigsdotter, U.K., Ekholm, O., Schipperijn, J., Toftager, M., Kamper-Jørgensen, F., & Randrup, T.B. (2010). Health promoting outdoor environments—associations between green space, and health, health-related quality of life and stress based on a Danish national representative survey. *Scandinavian Journal of Public Health*, *38*(4), 411–417. doi:10.1177/1403494810367468

Tabachnick, B.G., & Fidell, L.S. (2007). *Using multivariate statistics* (5th edn.). Boston, MA: Pearson Education.

Takano, T., Nakamura, K., & Watanabe, M. (2002). Urban residential environments and senior citizens' longevity in megacity areas: The importance of walkable green spaces. *Journal of Epidemiology and Community Health*, *56*(12), 913–918. doi:10.1136/jech.56.12.913

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:10.1021/es102947t

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: A systematic review. *Public Health*, *121*(12), 909–922. doi:10.1016/j.puhe.2007.04.009

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., & Kagawa, T. (2014). The influence of urban green environments on stress relief measures: A

field experiment. *Journal of Environmental Psychology*, *38*, 1–9. doi:10.1016/j.jenvp.2013.12.005

Ulrich, R.S. (1983). Aesthetic and affective response to natural environment. *Human Behavior & Environment: Advances in Theory & Research*, *6*, 85–125.

Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, *11*(3), 201–230. doi:10.1016/S0272-4944(05)80184-7

Väätäinen, S., Tuomilehto, H., Saramies, J., Tuomilehto, J., Uusitalo, H., Hussi, E. et al. (2013). The health-related quality-of-life impact of nocturnal awakenings in the middle-aged and older Finnish population. *Quality of Life Research*, *22*(10), 2737–2748. doi:10.1007/s11136-013-0404-y

Van Dillen, S.M.E., de Vries, S., Groenewegen, P.P., & Spreeuwenberg, P. (2012). Greenspace in urban neighbourhoods and residents' health: Adding quality to quantity. *Journal of Epidemiology and Community Health*, *66*(6), e8. doi:10.1136/jech.2009.104695

Van Herzele, A., & de Vries, S. (2012). Linking green space to health: A comparative study of two urban neighbourhoods in Ghent, Belgium. *Population and Environment*, *34*(2), 171–193. doi:10.1007/s11111-011-0153-1

Virtanen, V., Nyberg, R., Salonen, R., Neuvonen, M., & Sievänen, T. (2011). LVVI 2—seurantatutkimuksen aineisto ja menetelmät [The data and methods of the LVVI2 follow-up survey]. In T. Sievänen, & M. Neuvonen (Eds.), *Luonnon virkistyskäyttö 2010* [Outdoor recreation 2010] (pp. 19–36). Vantaa: Metsäntutkimuslaitos.

Ward Thompson, C., & Aspinall, P.A. (2011). Natural environments and their impact on activity, health, and quality of life. *Applied Psychology: Health and Well-Being*, *3*(3), 230–260. doi:10.1111/j.1758-0854.2011.01053.x

Ward Thompson, C., Roe, J., Aspinall, P., Mitchell, R., Clow, A., & Miller, D. (2012). More green space is linked to less stress in deprived communities: Evidence from salivary cortisol patterns. *Landscape and Urban Planning*, *105*(3), 221–229. doi:10.1016/j.landurbplan.2011.12.015

White, M.P., Alcock, I., Wheeler, B.W., & Depledge, M.H. (2013). Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. *Psychological Science*, *24*(6), 920–928. doi:10.1177/0956797612464659

Yu, C. (2002). Evaluating cutoff criteria of model fit indices for latent variable models with binary and continuous outcomes. Doctoral dissertation, University of California, Los Angeles.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix 1. Scale for emotional well-being (RAND-36 subscale; Hays et al., 1992), Scale for general activity (adapted from Saltin & Grimby, 1968).

Appendix 2a. Correlations between the observed independent variables (Spearman if one or both of the variable pair are ordinal, Pearson in italics), $n = 2070$.

Appendix 2b. Spearman correlations between the outcome variables (emotional well-being as the summary score of the five RAND-36 items), $n = 2070$.

Appendix 3a. Diagram of model 1. $\chi^2 = 405$, $df = 25$, $p < 0.0001$, CFI = 0.97, RMSEA = 0.09. Only significant ($p < 0.05$) connections are shown (arrows). The regression coefficients between independent and dependent variables are provided in Table 3.

Appendix 3b. Diagram of model 2. $\chi^2 = 388$, $df = 29$, $p < 0.0001$, CFI = 0.97, RMSEA = 0.08. Only significant ($p < 0.05$) connections are shown (arrows). The dashed arrow represents a negative connection. The regression coefficients between independent and dependent variables are provided in Table 3.

Appendix 3c. Diagram of model 3. $\chi^2 = 463$, $df = 43$, $p < 0.0001$, CFI = 0.97, RMSEA = 0.07. Only significant ($p < 0.05$) connections are shown (arrows). The dashed arrow represents a negative connection. The regression coefficients between independent and dependent variables are provided in Table 3.

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Restoration, well-being, and everyday physical activity in indoor, built outdoor and natural outdoor settings

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ABSTRACT

Physical activity in natural settings has been found in experimental research to be more restorative than physical activity in built indoor or outdoor settings, yet we lack evidence of this in everyday life. In this study we examined recalled restoration (with the 9-item Restoration Outcome Scale) of the most recent physical activity session in indoor, built outdoor and natural outdoor settings using measurement invariance tests (n = 2577). We also compared the relationships between restoration, emotional well-being and frequency of physical activity in these groups. Recalled restoration formed two factors, Restorativeness and Assurance, in all groups, with equal loadings but partly varying item-specific means. Restorativeness was positively connected to emotional well-being in all settings but it did not explain the connection between well-being and physical activity in natural settings. Future studies could explore in more detail how emotional well-being and repeated restoration in different types of environments intertwine.

1. Introduction

Contact with nature has consistently shown a positive correlation with well-being (Hartig, Mitchell, de Vries, & Frumkin, 2014). A recent synthesis identified three major pathways that explain this correlation: harm reduction (such as less pollution and noise), psychological restoration (attention restoration, stress reduction), and capacity building (such as social cohesion and physical activity; Markevych et al., 2017). These different pathways intertwine and may be mutually reinforcing. For example, natural environments are often conducive to physical activity, known to enhance well-being, and they have also been suggested to bring an added value to the known benefits of physical activity in relation to built indoor or outdoor environments (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Fox, 1999; Markevych et al., 2017; Pasanen, Tyrväinen, & Korpela, 2014; Thompson Coon et al., 2011). This added value has been explained by experienced psychological restoration, covered by two well-known theories within environmental psychology (Markevych et al., 2017). Ulrich's stress reduction theory (STR) describes a restorative experience as both psychologically and physically reduced stress (Ulrich, 1983; Ulrich et al., 1991). Kaplan and Kaplan's attention restoration theory (ART) sees stress as depleted attentional capacities which recover and are replenished involuntarily and effortlessly during a restorative experience (Kaplan & Kaplan, 1989; Kaplan, 1995). However, the majority of the evidence indicating that physical activity in natural settings is more restorative than physical activity in built indoor and outdoor settings is experimental, and observational evidence from restorative everyday experiences is lacking (Markevych et al., 2017). We do not know if restorative experiences through physical activity differ in everyday life when individuals have themselves chosen the activity and its setting.

Restoration is a short-term, mood-like state involving affective, physiological and attention restoration (Kaplan & Kaplan, 1989). These different aspects of restoration have been integrated in the Restoration Outcome Scale (Korpela, Ylén, Tyrväinen, & Silvennoinen, 2008), widely used in empirical research on restorative environments. The scale originally consisted of six items deriving from SRT and ART (Korpela et al., 2008; cf.; Hartig, Lindblom, & Ovefelt, 1998) and it was later extended into a 9-item version based on empirical evidence. The additional items measure vitality (an energetic positive state) and self-confidence (Korpela & Ylén, 2009), both consistently found to improve after contact with restorative (natural) environments (Barton & Pretty, 2010; Ryan et al., 2010). Restoration is a multifaceted experience and precise knowledge of the effects of nature on these different aspects would help to better evaluate the contributions of each component in the restorative process. How these additional concepts, vitality and self-confidence, relate to and interact with each other and the stress- and attention-related concepts has nevertheless not been examined to date to our knowledge.

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The theories and the majority of the applied research on restorative environments have focused on examining natural settings (Kaplan & Kaplan, 1989; San Juan, Subiza-Pérez, & Vozmediano, 2017; Ulrich, 1983). The restorative potential of built urban settings has been largely ignored, and often unpleasant urban scenes have been chosen merely to highlight the restorative qualities of nature (Karmanov & Hamel, 2008; San Juan et al., 2017). As recent evidence suggests that urban settings can also be restorative (Stigsdotter, Corazon, Sidenius, Kristiansen, & Grahn, 2017), there is a need to evaluate whether they provide restoration on similar aspects as natural settings. Similarly, the restorative potential of physical activity in indoor environments has been underinvestigated (Hug, Hartig, Hansmann, Seeland, & Hornung, 2009). Physical activity indoors has become more and more popular in recent decades in Finland, while the share of physical activity in natural settings has decreased (Husu, Paronen, Suni, & Vasankari, 2011). To assess if and how different types of environments for physical activity support our everyday restoration, we examine recalled restoration after physical activity in indoor, built outdoor and natural outdoor environments.

Both situational and individual factors play a role in what kind of environments we choose for physical activity. Not all physical activity can be conducted in (natural) outdoor settings due, for example, to weather, seasonal variation and lack of facilities. These constraints reflect the activities conducted: the most common activities in indoor environments are gymnastics and swimming, whereas in outdoor environments people prefer to walk, cycle and ski (Husu et al., 2011). Individual characteristics, such as identifying with the natural or urban, influence the types of environments we choose to visit and how restored we feel after visiting them (Morton, van der Bles, & Haslam, 2017). Furthermore, individuals may use natural and built, indoor or outdoor environments for different reasons and restoration needs (Hartig et al., 2014; Markevych et al., 2017). Having different motives for physical activity such as maintaining physical fitness and reducing stress does not, however, exclude the possibility of experiencing restoration, but restoration may be qualitatively different after physical activity conducted for different reasons in different types of environments (Markevych et al., 2017; Pasanen, Neuvonen, & Korpela, 2017).

One way to disentangle the potentially different restorative qualities that built and natural environments may support is to assess restoration with more detailed methods. Experimental studies often compute summary scores of different psychometric scales measuring restorative outcomes. Summary scores, even though useful in some cases, can mask differences between the items within a scale by assigning equal weight to each variable (Marsh, Lüdtke, Nagengast, Morin, & Von Davier, 2013; Williams & O'Boyle, 2008). More refined methods that assess the qualities within and between scales, such as structural equation modelling (SEM) have become common in psychological research and their use in environmental psychology has been encouraged (Hine, Corral-Verdugo, Bhullar, & Frias-Armenta, 2016; Markevych et al., 2017). With SEM we can assess if and how items within a scale intercorrelate and compare the correlative structures between different groups by a methodology known as measurement invariance (Kline, 2016). We use these measurement invariance methods in the first part of this study to explore the qualitative and quantitative differences in restorative experiences after everyday physical activity in different types of environments.

Restorative experiences may be important for our everyday coping and resource management (Hartig et al., 2014). Hence an underlying idea in restorative environments research has been that experiencing restoration (in natural settings) repeatedly supports emotional well-being in the longer-term (Hartig et al., 2014; Markevych et al., 2017). We call this the *repeated restoration hypothesis*. This idea that recurrent restorative experiences accumulate over time into greater well-being has not, however, been properly addressed in past research (Markevych et al., 2017). There is some experimental evidence to suggest that perceived restoration mediates the increase in positive affect followed by exposure to natural rather than urban, virtual settings (McAllister, Bhullar, & Schutte, 2017) but similar findings from everyday life are scarcer. Tentative evidence was provided in a study by Korpela, Borodulin, Neuvonen, Paronen, and Tyrväinen (2014), where recalled restoration from the most recent visit to nature mediated the relationship between the frequency of visiting natural environments and emotional well-being. This study, however, was limited to natural settings.

Although the evidence for repeated restoration is so far scarce, we know more about the direct connection between well-being and exposure to natural settings. Residents in greener neighbourhoods constantly rate their mental well-being better than those in less green areas (van den Berg et al., 2015). Similarly, more frequent PA in natural settings (but not in indoor or built outdoor environments) has been associated with greater emotional well-being (Pasanen et al., 2014). Yet the evidence is partly ambiguous. Mitchell (2013) found that regular physical activity in natural environments was connected to a reduced risk of poor mental health, whereas regular physical activity indoors was connected to positive aspects of well-being. One possible explanation for these inconsistent findings could again be that different types of environments induce different types of positive responses (Mitchell, 2013). We know that physical activity in general, regardless of the environment, is moderately related to better emotional well-being (Fox, 1999; Penedo & Dahn, 2005). This connection is mediated by mood enhancement and increased self-esteem, indicating that the positive effects of physical activity on mood and self-esteem accumulate over time into greater longer-term well-being (Fox, 1999). The 'repeated restoration' hypothesis, in turn, suggests that regular physical activity in natural environments is connected to emotional well-being specifically via repeated restorative experiences. Is this connection exclusive to, or stronger, in natural environments than in other settings? This question is the focus of the second part of our study.

Our study makes two main contributions to the research on restorative environments. First, we examine in detail whether restorative outcomes of recent everyday physical activity differ in quantity and/or quality between three types environments: indoor (for example, home or a gym), built outdoor (streets, sports fields) and natural outdoor settings (forests, urban parks). Second, we examine the 'repeated restoration' hypothesis by assessing whether the frequency of physical activity and recalled restoration in indoor, built outdoor and natural outdoor settings are related to emotional well-being in different ways.

2. Materials and methods

2.1. Data

We used two rounds from the 'Outdoor recreation demand inventory', collected in winter and spring/summer 2009 by Statistics Finland (Sievänen & Neuvonen, 2011). In these two rounds the survey was sent to a sample of 8000 randomly selected Finnish citizens aged 15–74 years, drawn from the population registry. With 3060 respondents, the response rate was 38%. The response rates were higher for women than men, and younger age groups were underrepresented in comparison to older age groups (Virtanen, Nyberg, Salonen, Neuvonen, & Sievänen, 2011). However, these biases were relatively small, and the interviewed sample of the non-respondents revealed no differences in the recreation patterns of the respondents and non-respondents (Virtanen et al., 2011). We excluded those respondents who reported physical handicaps that prevented them from engaging in physical activity outdoors. Due to this screening and missing responses, the present analyses included 2568–2577 respondents (Table 1).

2.2. Measures

Recalled restoration after the most recent physical activity was measured with 9-item Restoration Outcome Scale where the

Table 1
Sample descriptives.

Variable	Range or category	n	Mean (SD) or %
Gender	Male	1164	45.2
	Female	1413	54.8
Age	15–74 years	2577	45.7 (16.2)
Monthly household income (€)[a]	≤1000	136	5.3
	1001–3000	757	29.4
	3001–5000	695	27.0
	5001–7000	393	15.3
	> 7000	235	9.1
	Missing/don't know/ refused	361	14.0

[a] Categories have been combined.

respondents are asked to rate to which extent each statement describes their experiences (Korpela et al., 2008). According to earlier studies on restoration (Hartig et al., 1998; Staats, Kieviet, & Hartig, 2003), of the six original items, three measure relaxation and calmness (a, c, and d; Table 3), one attention restoration (b) and two clearing one's thoughts (e and f). Two of the additional items measure vitality (i and h) and one self-confidence (g) (Korpela & Ylén, 2009; Korpela, 1992; Ryan et al., 2010). All items are evaluated on a 7-point scale, with greater values indicating more restoration.

Emotional well-being was measured by the respective subscale in the validated Short-Form Health Survey (also known as the RAND 36-item health survey; Hays, Sherbourne, & Mazel, 1993; Finnish validations by Aalto, Aro, & Teperi, 1999). The subscale for emotional well-being consists of five statements, evaluated on a 6-point scale related to respondents' well-being in the past four weeks. Two items measure positive emotional state (e.g. "Have you felt calm and peaceful?") and three items negative emotional state (e.g. "Have you felt downhearted and blue?"); these were inverted in the analyses so that higher values indicated greater well-being.

The type of environment of the most recent physical activity was used to group respondents into three groups: *indoors* (n = 592), *outdoors in natural settings* (n = 1188) and *outdoors in built settings* (n = 752). We excluded the physical activity that took place in one's own front/backyard since we had no information about whether these were built or natural.

For an estimate of the *weekly frequency of leisure time physical activity indoors, outdoors in built settings and outdoors in natural settings*, the respondents were asked to estimate the percentage of their leisure-time physical activity that takes place in these three types of environments. These shares were multiplied by the weekly frequency of leisure-time physical activity to gain an estimate of how many times per week the respondents engaged in physical activity in indoor, built outdoor and natural outdoor settings (see Pasanen et al., 2014 for more details).

Age, *gender* and *household income* (in thousands) were not of primary interest in this study but they were added as socio-demographic covariates in the sensitivity analyses to ensure that the connections found were not due to these potentially confounding factors. For example, gender, age and income are not necessarily related to emotional well-being (Aalto et al., 1999) but may be associated with the types of physical activity that we engage in, the settings for physical activity we can access and how we respond to these settings (Barton & Pretty, 2010; Husu et al., 2011). However, their role in the environment-well-being relationship has reportedly been mixed (van den Berg et al., 2015; Markevych et al., 2017).

2.3. Statistical analyses

In all analyses the data was grouped according to the location of the most recent physical activity – indoors, outdoors in built settings and outdoors in natural settings. The analyses were conducted using Mplus 8 with maximum likelihood estimator with robust standard errors, suitable for continuous, non-normally distributed variables (Muthen & Muthen, 1998–2012). As our data is relatively large and we conduct multiple tests, we use a 99% confidence level as the criterion for "statistical significance". We also examine and report the 99% confidence intervals (CI) which, in the case of this estimator, are equivalent to the generally recommended bootstrapped CIs (Muthen & Muthen, 1998–2012).

2.3.1. Measurement invariance tests

The items in the 9-item Restoration Outcome Scale comprise different aspects of restoration that are related but separate, and accordingly, exploratory SEM was appropriate (Asparouhov & Muthén, 2009; Davidov, Meuleman, Cieciuch, Schmidt, & Billiet, 2014; Marsh et al., 2013). We followed the approach taken by Asparouhov and Muthén (2009; Muthén & Muthén, 2012) to assess the measurement invariance of the 9-item Restoration Outcome Scale responses based on physical activity in indoor, built outdoor, and natural outdoor settings. We examined five types of measurement invariance where each successive model assumes more equivalence (invariance) between the groups (Muthén & Muthén, 2012). If the added constraints improve model fit, we can interpret that the constrained parameter(s) are equal across these groups. In Step 1, we tested the optimal number of factors and whether the same items loaded on the same factor(s) by specifying 1–3 exploratory factors (Korpela & Ylén, 2009; Korpela et al., 2008) for each group individually but simultaneously. The following models constrained factor loadings (Step 2), item-specific intercepts (Step 3), factor variances and covariances (Step 4) and factor means (Step 5), and tested their equivalence across groups (Muthén & Muthén, 2012).

We examine model fit and its changes with several recommended criteria: the χ^2 test of overall fit, the Satorra-Bentler corrected χ^2-difference tests for nested models, a set of recommended fit indices and normalised covariance residuals ($|\ > 1.96|$ considered large) (Chen, 2007; Kline, 2016; Satorra & Bentler, 2010). All fit indices are based on the χ^2 value that has been criticised in the case of both large and unequal sample sizes in measurement invariance tests and hence is interpreted with caution (Chen, 2007). The recommendations for cut-off values that indicate good model fit vary between $\leq$0.05/.06/.08 for the Root Mean Square Error of Approximation (RMSEA), $\geq$0.90/.95 for the Comparative Fit Index (CFI) and the Tucker-Lewis Fit Index (TLI) and $\leq$0.08/.10 for Standardised Root Mean Square Residual (SRMR; Asparouhov & Muthén, 2009; Kline, 2016; Rutkowski & Svetina, 2014). When comparing nested models with different levels of measurement invariance, the model fit is assumed to remain approximately equal if the χ^2-difference test is non-significant ($p > .01$), and the differences in the fit indices are $> -0.010/-0.005$ for CFI, $< 0.010/.015$ for RMSEA and < 0.005–0.030 for SRMR, depending on the type of invariance (Chen, 2007; Cheung & Rensvold, 2002). With these criteria, we choose the best-fitting model from Steps 1–5 for the second phase of the analysis (Davidov et al., 2014).

2.3.2. Examining the 'repeated restoration' hypothesis

Next we specify a multigroup exploratory SEM model with direct relationships between emotional well-being and recalled restoration after the most recent physical activity indoors, outdoors in built settings and outdoors in natural settings, controlling for the weekly frequency of physical activity in that environment. For recalled restoration, we use the factor structure from the previous analysis, and emotional well-being is specified as a latent confirmatory factor with equal loadings and intercepts in all groups.

We examine the following hypotheses: 1) more frequent physical activity is associated with stronger recalled restoration after the most recent physical activity, 2) recalled restoration is positively connected to emotional well-being, 3) more frequent physical activity is connected to better emotional well-being and 4) recalled restoration mediates the relationship between physical activity and emotional well-being (Fox,

1999; Markevych et al., 2017). Following the 'repeated restoration' hypothesis, we assume that the association between recalled restoration and emotional well-being (Hypothesis 2) is the strongest in the nature group (Pasanen et al., 2014). We also compared between-group differences in the weekly frequency of physical activity, recalled restoration and emotional well-being. Although our model is a mediation model in which we examine indirect connections (Hypothesis 4), and the theories suggest a temporal order where repeated physical activity sessions lead to greater emotional well-being via repeated restorative experiences (Markevych et al., 2017), with cross-sectional data we can only assess correlational relationships.

2.3.3. Sensitivity analyses

We specified four alternative models to ensure that our main results were not affected by misspecifications. First, regarding the 9-item Restoration Outcome Scale, most our estimated models showed two large, unexpected normalised covariance residuals. We re-ran the models allowing the error variances of these problematic items to correlate. Second, in Emotional well-being, the residual variance of the happiness item correlated substantially with the residual variance of other items, and we consequently re-ran the model without this item. Third, to see if the positive connections found were not simply due to some groups engaging in physical activity more frequently than others, we ran the models using the total, instead of setting-specific, frequency of weekly physical activity. Fourth, to ensure our main results were not due to potentially confounding socio-demographic factors, we specified one model with gender, age and income as covariates for both recalled restoration and emotional well-being (van den Berg et al., 2015; Markevych et al., 2017).

3. Results

3.1. Measurement invariance of the 9-item Restoration Outcome Scale

Following the criteria in Section 2.3, the best fitting model was a partially invariant model in Step 4 (Table 2). This model (Table 3) consisted of two factors (Step 1) whose loadings were equal (Step 2), all but three intercepts were equal (Step 3) and factor means varied between the groups (cf. Step 5). Regarding the varying intercepts, calmness (a) was the greatest after physical activity in natural settings, and forgetting everyday worries (e) and gaining self-confidence (g) were the greatest after physical activity indoors. In terms of the factors means, Factor 1 was greater in the nature group than in the built outdoor group, whereas Factor 2 was equal across groups.

Content-wise, Factor 1 represented the original, 6-item Restoration Outcome Scale and we labelled it 'Restorativeness' (Fig. 1, Table 3). Factor 2 was named 'Assurance' because items on self-confidence (g) and gaining faith in tomorrow (h) loaded on it the highest. Item i 'My vitality and energy increased' loaded moderately on both factors (0.54–0.65). The correlation between the factors was high ($r = 0.77$).

All 2-factor models (1b-5; Table 2) showed acceptable fit with the data in all criteria except the χ^2 test (Chen, 2007). Most analyses showed large normalised covariance residuals between items (a, b) and items (e,f) and we conducted sensitivity analysis to ensure our main results were not affected by these (all residuals, converted into correlation-metric, are provided in Appendix Table A.1).

3.2. The repeated restoration hypothesis

As we hypothesised (1), the connections between the frequency of physical activity and Restorativeness and Assurance of the most recent bout of physical activity were positive in all groups, with no differences between the groups (Fig. 1; Appendix Table B.1). Similarly, Hypothesis 2 was supported because greater Restorativeness was associated with better Emotional well-being, although contrary to our assumption, this connection was equally strong in all environments and non-significant for Assurance. Hypothesis 3 was supported only in the nature group: after controlling for recalled restoration, Emotional well-being was positively associated with more frequent physical activity in natural settings but not indoors or in built outdoor settings. As for Hypothesis 4, Restorativeness mediated the connection between frequency of physical activity and Emotional well-being in indoor and built outdoor but not natural settings (Table 4).

The model explained 6.8%–11.4% of Emotional well-being within the groups (Table 4), indicating a small yet practically meaningful effect size (Ferguson, 2009). The model fit indices were close to those of the measurement invariance model. 'Happiness' in Emotional well-being had a large residual covariance with other items and we allowed its residual variance to correlate with 'Calmness', the other positively-phrased item within the same scale (see Fig. 1), and inspected a sensitivity model without this item (Section 3.3).

Regarding differences in means between the groups, Emotional well-being and Assurance were equal (Table 4). The weekly frequency of physical activity was equal in nature (1.24 times; 99% CI [1.15; 1.32]) and indoors (1.31 [1.2; 1.43]) but significantly lower in built outdoor settings (0.99 [0.89; 1.08]). Contrary to the measurement invariance model, Restorativeness was greater after physical activity in natural settings than indoors but not built outdoor settings (Table 4). These differences from the previous model are most likely due to the effect being small, and thus sensitive to even small differences in estimation. With 95% CIs, Restorativeness was evaluated the greatest after physical activity in nature in both models.

3.3. Sensitivity analyses

None of the sensitivity models showed substantial differences to the reported model. We provide the estimates for Sensitivity model 4 (with socio-demographic covariates) in Appendix Figure C.1 and Table C.1 as they may be useful for future research on confounders in people-environment studies.

Table 2
Model fits for measurement invariance tests for 9-item Restoration Outcome Scale. The row in bold face represents the best-fitting model.

Step	Description	χ^2 value	df	p	χ^2 diff. test, p^*	RMSEA	CFI	TLI	SRMR
1a	Individual models, 1 factor	1086	81	< .001		.12	.89	.86	.05
1b	Individual models, 2 factors	382	57	< .001	< .001	.08	.97	.93	.02
2	Equal loadings	423	85	< .001	.011	.07	.96	.95	.03
3a	Equal item intercepts	526	103	< .001	< .001	.07	.96	.95	.05
3b	Equal item intercepts[a]	460	97	< .001	< .001	.07	.96	.96	.04
4	**Equal factors variances and covariances[a]**	**448**	**99**	**< .001**	**	**.07**	**.96**	**.96**	**.05**
5	Equal factor means[a]	463	103	< .001	.003	.06	.96	.96	.05

* Satorra-Bentler corrected, comparison to the previous model. Significant value: the model with less df fits the data better.
** Could not be calculated due to a negative difference in the χ^2 values between models 4 and 3b,. It is, however, evident that model 4 fits the data better because it has greater df but smaller χ^2 value.
[a]Intercepts for items a, e and g freely estimated between groups.

Table 3
The factor structure of the best-fitting measurement invariance model (Model 4, Table 2). Estimates in bold face: statistically significant ($p < .01$) difference from the other group(s), or loading > 0.50.

Item	Loadings		Estimated means			Std. residual variances		
	Factor 1 Restorativeness	Factor 2 Assurance	Indoor	Built outdoor	Nature	Indoor	Built outdoor	Nature
a) I calmed down	**0.96**	−0.03	4.87	**5.01**[i]	**5.12**[i, b]	.49	.39	.41
b) My concentration and alertness increased	**0.94**	0.06	4.71			.36	.34	.35
c) I gained new spirit for my everyday routines	**1.04**	0.01	4.97			.30	.25	.26
d) I felt restored and relaxed	**1.06**	−0.06	5.00			.33	.25	.26
e) I forgot everyday worries	**0.74**	0.31	**4.94**[b, n]	4.70	4.76	.53	.49	.49
f) My thoughts were clarified	**0.71**	0.40	4.70			.32	.30	.29
g) I became more self-confident	0.06	**1.17**	**4.54**[b, n]	4.35	4.33	.25	.22	.23
h) I gained faith in tomorrow	−0.01	**1.30**	4.49			.14	.12	.10
i) My vitality and energy increased	**0.54**	**0.65**	4.86			.24	.24	.26
Factor means (99% CIs)	Indoors		0*			0*		
	Built outdoor		−0.02 [−0.17;0.14]			−0.08 [−0.23;0.07]		
	Nature		0.14 [−0.01;0.28]			0.03 [−0.11;0.17]		
	Difference (built-nature)		**−0.15 [−0.28;−0.03]**			−0.11 [−0.23;0.02]		

* constrained for identification.
[n] greater than in 'nature'.
[i] greater than 'indoor'.
[b] greater than 'built outdoor' settings.

4. Discussion and conclusions

4.1. Discussion and limitations

Our first main result was that not all aspects of recalled restoration were rated greater after physical activity in natural settings compared with indoor and built outdoor environments. Assurance was rated equal in all settings, and items measuring self-confidence and forgetting everyday worries were felt most strongly after physical activity indoors. One possible explanation for these results may derive from different types of activities. Indoor settings may support purposeful activities where monitoring one's personal development is straightforward, potentially leading to increased self-confidence. For example, at the gym people inevitably know how heavy weights they are lifting, whereas during a nature walk they do not need to monitor their performance or progress (unless they wish to). The idea that indoor environments may serve different needs than outdoor environments is in line with Mitchell's results (2013). These results encourage further examination of restorative qualities of built indoor and outdoor environments.

The second main result agrees with a long line of experimental research supporting the restorative role of natural environments (Hartig et al., 2014). The level of Restorativeness (corresponding to the original, 6-item Restoration Outcome Scale) after everyday physical activity was slightly greater when conducted in natural settings than in indoor or built outdoor environments, even when the activity and its setting had been (presumably) freely chosen. This result accords with the meta-analyses comparing natural outdoor environments to indoor and/or built outdoor environments (Bowler et al., 2010; Thompson Coon et al., 2011). What our study adds to the discussion is that the restorative qualities of physical activity in natural settings are not solely due to biases in experimental research such as choosing an unpleasant built comparison setting.

Our third main finding was that the 'repeated restoration' hypothesis was supported in all settings: experiencing greater Restorativeness was connected equally strongly to increased emotional well-being in all three settings when controlling for the frequency of physical activity in

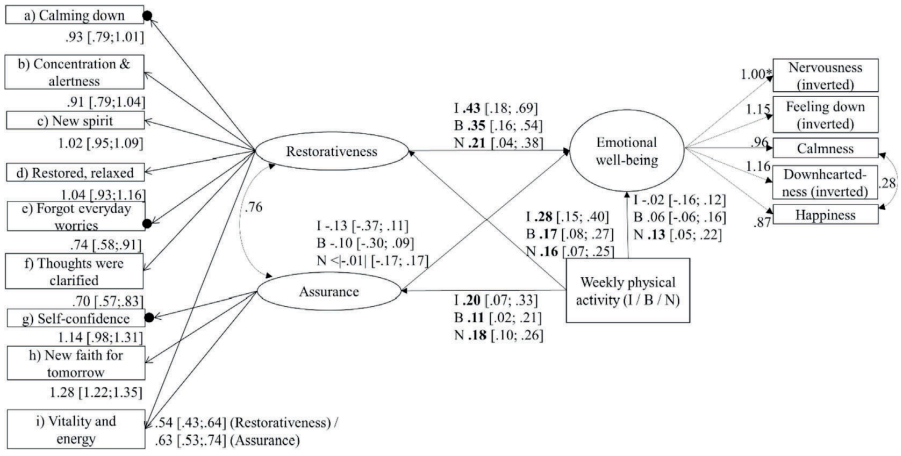

Fig. 1. Multigroup exploratory SEM model estimates (standardised with 99% CIs) for the relationships between Emotional well-being, Restorativeness and Assurance, and frequency of physical activity in indoor (I), built outdoor (B) and natural outdoor (N) environments. $\chi^2 = 964.4$, df = 291, $p < .001$; RMSEA = 0.05; CFI = 0.96; TLI = 0.96; SRMR = 0.05. Black dot: between-group intercepts vary. For simplicity, only (unstandardised) loadings > .50 shown. *constrained to 1.

Table 4
Estimated factor means, mediations from weekly frequency of physical activity to emotional well-being) and explained variances of the model testing the "repeated restoration" hypothesis (Fig. 1). Estimates in bold face: $p < .01$.

		Mean [99% CI]	(Standardised) indirect connection to emotional well-being [99% CI]	R^2 (%)
Restorativeness	Indoor	0[a]	**.12** [.03; .21]	7.6
	Built outdoor	.16 [−.10;.42]	**.06** [.02; .10]	3.0
	Nature	**.31** [.06;.56]	.03 [−.001; .07]	2.5
Assurance	Indoor	0[a]	−.03 [−.08; .03]	3.9
	Built outdoor	.06 [−.19;.31]	−.01 [−.04; .01]	1.3
	Nature	.07 [−.17;.32]	< .001 [−.03; .03]	3.2
Emotional well-being	Indoor	0[a]		11.4
	Built outdoor	.05 [−.14;.24]		8.3
	Nature	.00 [−.18;.18]		6.8

[a] Constrained for model identification.

the respective setting. However, an interesting detail was that only in the 'natural environment' group was the relationship between weekly physical activity and emotional well-being significantly positive, that is, not fully explained by Restorativeness. This finding suggests that other factors beyond restoration explain the positive association between repeated physical activity in natural settings and emotional well-being (Pasanen et al., 2014). At this point, we can only speculate what these may be. Alternatives identified in earlier research specific to natural environments include social aspects, differences in exposure duration (White, Pahl, Ashbullby, Herbert, & Depledge, 2013), identity-related reasons such as nature-connectedness (Morton et al., 2017), environmental qualities that support well-being (van den Berg et al., 2015), psychological factors such as motives and the focus of attention (Pasanen et al., 2017) and positive emotional responses other than restoration (Richardson, McEwan, Maratos, & Sheffield, 2016).

Regarding the psychometric properties of the 9-item Restoration Outcome Scale, the present data supported using the original six items as one factor (in line with Korpela et al., 2008) and two of the additional items as another, indicating assurance. The third additional item, increased vitality and energy, added ambiguity in the scale because it was not clearly part of either factor, and was probably one reason for the strong correlation between the two factors. Prospective studies might consider removing this item from the scale. Nevertheless, the results encourage further use of measurement invariance testing for evaluating the quality and quantity of restoration after visiting different types of settings. In this study, we could infer that the items in the 9-item Restoration Outcome Scale correlate similarly regardless of the type of setting but that not all item means are equal. These item-level differences may be useful for highlighting the benefits of physical activity in other than natural settings. For example, the idea of gaining self-confidence is a novel example of psychological "capacity building" in people-environment studies (Markevych et al., 2017), worth further investigation.

It is evident that this study had some weaknesses. First, the information about the bouts of physical activity that the restoration evaluations were based on were limited to the type of setting. More specific information such as duration (White et al., 2013), company (White et al., 2013), level of physical strain (Fox, 1999), experienced stress (Ulrich, 1983), season and weather would have been useful to include in the analyses. Second, the study was cross-sectional and all results were based on correlations, not causalities. Third, self-reports on physical activity are generally overestimated compared with objective measures, which may have caused some bias in the analyses (Hagstromer, Ainsworth, Oja, & Sjostrom, 2010). Nevertheless, subjective and objective measures generally correlate moderately, and the tendency to exaggerate the frequency of physical activity is similar in different demographic groups (Hagstromer et al., 2010) and probably also in the different environments used in this study. Fourth, the restoration evaluations were based on single bouts of physical activity and we do not know how well they reflected the respondents' "average" restorative experiences, which may cause some bias when we assess their relationship with emotional well-being. Future studies could assess restoration after physical activity repeatedly to avoid this potential bias. Fifth, the environmental categories were quite broad and based on subjective evaluations. Using a single term "natural" to describe the variety of different scenery containing little-to-no man-made features has been criticised (Markevych et al., 2017), and the same applies to grouping all indoor and built outdoor environments into one category. This categorisation is, nevertheless, in line with existing research (Bowler et al., 2010; Thompson Coon et al., 2011), and our population-level data enabled exploring broader trends within a wide range of respondents, environments and activities.

4.2. Conclusions

We examined whether recalled restoration after everyday physical activity in indoor, built outdoor and natural settings varies in quantity and quality, and how recalled restoration is connected to emotional well-being. The results corroborate experimental studies reporting that natural environments bring an added value to the known benefits of physical activity for mood and well-being (Bowler et al., 2010; Thompson Coon et al., 2011). However, indoor environments provided greater benefits for self-confidence and forgetting everyday worries than built or natural outdoor settings. Regardless of the type of environment, greater recalled restoration was connected to greater emotional well-being. This 'repeated restoration' hypothesis was thus not specific to natural environments, and moreover, recalled restoration did not explain the association between regular PA in natural settings and well-being.

The processes leading from momentary restoration to more general emotional well-being merit further research. In the everyday context, examining these associations with longitudinal designs such as diary studies could further our understanding of the interplay between well-being and restoration in specific settings. Such designs could also easily take into account more detailed information about the bouts of physical activity that have tentatively been shown to play a role in restoration evaluations, such as company, activity and duration (White et al., 2013). Our study was a preliminary effort to investigate nuanced differences in recalled restoration after everyday physical activity in different types settings. We call for future research to replicate these findings and to continue exploring the restorative qualities of physical activity in all kinds of spaces, built and natural, in greater detail.

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Declarations of interest

None.

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Appendix A

Table A.1
Estimated correlations (lower diagonal) and correlation residuals (upper diagonal) of the partial measurement invariance model in Step 4. In bold: large covariance residual in at least one group (normalised value > |1.96|).

	a	b	c	d	e	f	g	h	i
a) I calmed down		**.15/.06/.06**	−.02/−.08/−.02	.06/−.01/.01	−.01/−.05/.02	.00/−.01/−.03	.04/−.02/−.01	.02/−.01/.02	−.02/−.07/−.02
b) My concentration and alertness increased	.57/.64/.62		.04/−.02/.02	.02/−.04/−.05	−.04/−.03/−.04	.04/−.04/.00	.04/−.03/.04	.01/−.03/.02	−.02/−.05/−.02
c) I gained new spirit for my everyday routines	.60/.68/.66	.67/.70/.70		.01/.00/.01	−.01/−.06/−.03	.00/−.03/−.01	.03/−.02/−.01	.02/−.05/.01	.06/.02/.05
d) I restored and relaxed	.58/.68/.66	.65/.71/.69	.68/.75/.74		.05/−.03/.03	.04/−.04/−.01	.03/−.02/−.03	.03/−.03/.01	−.02/−.02/.04
e) I forgot everyday worries	.48/.55/.53	.54/.58/.57	.56/.61/.60	.54/.61/.60		**.10/.07/.09**	.00/.00/.01	.01/−.03/−.01	.01/−.04/−.01
f) My thoughts were clarified	.57/.63/.62	.64/.67/.67	.67/.70/.70	.64/.70/.69	.56/.60/.60		.01/.01/.04	.00/−.04/.00	.01/−.03/−.01
g) I became more self-confident	.48/.54/.52	.56/.58/.58	.58/.60/.60	.54/.59/.58	.53/.57/.56	.65/.68/.68		.00/.00/.00	.02/−.01/−.04
h) I gained faith in tomorrow	.50/.55/.55	.58/.60/.61	.60/.63/.63	.56/.61/.60	.56/.59/.59	.69/.71/.72	.80/.83/.83		.04/.01/−.01
i) My vitality and energy increased	.58/.63/.61	.66/.67/.66	.68/.70/.69	.65/.70/.68	.59/.62/.60	.71/.73/.72	.73/.74/.73	.77/.78/.77	

Note: The analysis is based on covariances but correlations are shown for more intuitive interpretation. In the models, the estimated covariances were constrained to equal across groups but the estimated correlations can differ due to variations in standard deviations between groups.

Appendix B

Table B.1
Unstandardised path estimates and their standard errors (s.e.) of the model testing the “repeated restoration” hypothesis (Fig. 1). Estimates in bold face: $p < .01$.

		Emotional well-being			Factor 1 Restorativeness			Factor 2 Assurance		
		Indoor	Built outdoor	Nature	Indoor	Built outdoor	Nature	Indoor	Built outdoor	Nature
Factor 1 Restorativeness	b	**0.31**	**0.23**	**0.14**						
	s.e.	0.07	0.05	0.05						
Factor 2 Assurance	b	−0.1	−0.07	0						
	s.e.	0.07	0.05	0.04						
Frequency of PA	b	−0.02	0.04	**0.08**	**0.27**	**0.18**	**0.15**	**0.19**	**0.12**	**0.17**
	s.e.	0.04	0.03	0.02	0.05	0.04	0.03	0.05	0.04	0.03

Appendix C. Sensitivity model 4

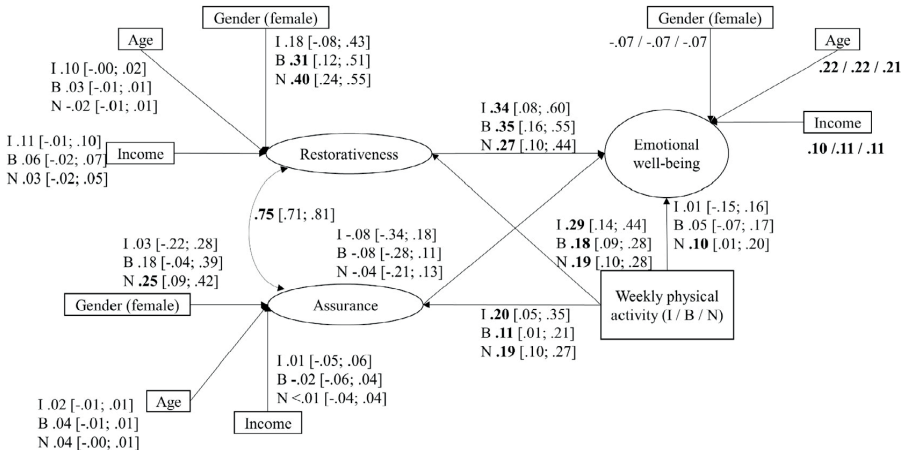

Fig. C.1. Sensitivity model 4, with socio-demographic covariates (n = 2211). Standardised estimates and 99% CIs in indoor (I), built outdoor (B), and natural outdoor (N) environments. For gender, only the outcome standardised. χ^2 = 1267.49, df = 405, p < .001, RMSEA = .054, CFI = .946, TLI = .941, SRMR = .056. For simplicity, the factor items not shown (similar to Fig. 1). R^2 (%): Restorativeness 11.2 / 6.0 / 7.5; Assurance 4.2 / 2.2 / 5.1; Emotional well-being 16.2 / 16.2 / 12.8, respectively.

Table C. 1
Unstandardised path estimates and their standard errors (s.e.) of Sensitivity model 4 with socio-demographic covariates (Figure C.1). Estimates in bold face: p < .01.

		Emotional well-being			Factor 1 Restorativeness			Factor 2 Assurance		
		Indoor	Built outdoor	Nature	Indoor	Built outdoor	Nature	Indoor	Built outdoor	Nature
Factor 1 Restorativeness	b	**.24**	**.23**	**.18**						
	s.e.	.07	.05	.05						
Factor 2 Assurance	b	−.06	−.06	−.03						
	s.e.	.07	.05	.05						
Frequency of physical activity	b	.01	.03	**.07**	**.29**	**.19**	**.18**	**.20**	**.12**	**.18**
	s.e.	.04	.03	.02	.06	.04	.04	.06	.04	.03
Gender(female)	b	−.05[a]			.19	**.32**	**.41**	.03	.18	**.26**
	s.e.	.03			.11	.08	.07	.10	.08	.07
Age	b	**.01** [a]			.01	< .01	< .01	< .01	< .01	< .01
	s.e.	< .01			< .01	< .01	< .01	< .01	< .01	< .01
Income (thousands)	b	**.03** [a]			.05	.03	.01	.01	−.01	< .01
	s.e.	.01			.02	.02	.01	.02	.02	.01

[a] Estimate constrained to equal across the groups.

References

Aalto, A., Aro, A., & Teperi, J. (1999). *RAND-36 as a measure of health-related quality of life. Reliability, construct validity and reference values in the Finnish general population. [RAND-36 terveyteen liittyvän elämänlaadun mittarina: Mittarin luotettavuus ja suomalaiset väestöarvot].* Helsinki: Stakes.

Asparouhov, T., & Muthén, B. (2009). Exploratory structural equation modeling. *Structural Equation Modeling: A Multidisciplinary Journal, 16*(3), 397–438. https://doi.org/10.1080/10705510903008204.

Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science & Technology, 44*(10), 3947–3955. https://doi.org/10.1021/es903183r.

van den Berg, M., Wendel-Vos, W., van Poppel, M., Kemper, H., van Mechelen, W., & Maas, J. (2015). Health benefits of green spaces in the living environment: A systematic review of epidemiological studies. *Urban Forestry and Urban Greening, 14*(4), 806–816. https://doi.org/10.1016/j.ufug.2015.07.008.

Bowler, D., Buyung-Ali, L., Knight, T., & Pullin, A. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health, 10*, 456–465. https://doi.org/10.1186/1471-2458-10-456.

Chen, F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal, 14*(3), 464–504. https://doi.org/10.1080/10705510701301834.

Cheung, G., & Rensvold, R. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling, 9*(2), 233–255.

Davidov, E., Meuleman, B., Cieciuch, J., Schmidt, P., & Billiet, J. (2014). Measurement equivalence in cross-national research. *Annual Review of Sociology, 40*.

Ferguson, C. J. (2009). An effect size primer: A guide for clinicians and researchers. *Professional Psychology: Research and Practice, 40*(5), 532.

Fox, K. R. (1999). The influence of physical activity on mental well-being. *Public Health Nutrition, 2*(3a), 411–418.

Hagstromer, M., Ainsworth, B. E., Oja, P., & Sjostrom, M. (2010). Comparison of a subjective and an objective measure of physical activity in a population sample. *Journal of Physical Activity and Health, 7*(4), 541–550. https://doi.org/10.1123/jpah.7.4.541.

Hartig, T., Lindblom, K., & Ovefelt, K. (1998). The home and near-home area offer restoration opportunities differentiated by gender. *Scandinavian Housing and Planning Research, 15*(4), 283–296.

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health, 35*(1), 207–228. https://doi.org/10.1146/annurev-publhealth-032013-182443.

Hays, R., Sherbourne, C., & Mazel, R. (1993). The rand 36-item health survey 1.0. *Health Economics, 2*(3), 217–227. https://doi.org/10.1002/hec.4730020305.

Hine, D., Corral-Verdugo, V., Bhullar, N., & Frias-Armenta, M. (2016). Advanced statistics for Environment-Behavior research. In R. Gifford (Ed.). *Research methods for environmental psychology* (pp. 369–388). Chichester, UK: Wiley Online Library.

Hug, S., 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. https://doi.org/10.1016/j.healthplace.2009.03.002.

Husu, P., Paronen, O., Suni, J., & Vasankari, T. (2011). Suomalaisten fyysinen aktiivisuus ja kunto 2010: Terveyttä edistävän liikunnan nykytila ja muutokset [Physical activity and fitness of Finns in 2010: Current status and changes in health-enhancing physical activity]. *Opetus- ja kulttuuriministeriön julkaisuja, 2011*, 15.

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

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

Karmanov, D., & Hamel, R. (2008). Assessing the restorative potential of contemporary urban environment(s): Beyond the nature versus urban dichotomy. *Landscape and Urban Planning, 86*(2), 115–125. https://doi.org/10.1016/j.landurbplan.2008.01.004.

Kline, R. (2016). *Principles and practice of structural equation modeling* (4th ed.). New York: Guilford Press.

Korpela, K. (1992). Adolescents' favourite places and environmental self-regulation. *Journal of Environmental Psychology, 12*(3), 249–258.

Korpela, K., Borodulin, K., Neuvonen, M., Paronen, O., & Tyrväinen, L. (2014). Analyzing the mediators between nature-based outdoor recreation and emotional well-being. *Journal of Environmental Psychology, 37*(0), 1–7. https://doi.org/10.1016/j.jenvp.2013.11.003.

Korpela, K., & Ylén, M. (2009). Effectiveness of favorite-place prescriptions: A field experiment. *American Journal of Preventive Medicine, 36*(5), 435–438. https://doi.org/10.1016/j.amepre.2009.01.022.

Korpela, K., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2008). Determinants of restorative experiences in everyday favorite places. *Health & Place, 14*(4), 636–652. https://doi.org/10.1016/j.healthplace.2007.10.008.

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., ... Fuertes, E. (2017). Exploring pathways linking greenspace to health: Theoretical and methodological guidance. *Environmental Research, 158*, 301–317. https://doi.org/10.1016/j.envres.2017.06.028.

Marsh, H., Lüdtke, O., Nagengast, B., Morin, A. J., & Von Davier, M. (2013). Why item parcels are (almost) never appropriate: Two wrongs do not make a right—camouflaging misspecification with item parcels in CFA models. *Psychological Methods, 18*(3), 257. https://doi.org/10.1037/a0032773.

McAllister, E., Bhullar, N., & Schutte, N. S. (2017). Into the woods or a stroll in the park: How virtual contact with nature impacts positive and negative affect. *International Journal of Environmental Research and Public Health, 14*(7), 786. https://doi.org/10.3390/ijerph14070786.

Mitchell, R. (2013). Is physical activity in natural environments better for mental health than physical activity in other environments? *Social Science & Medicine, 91*, 130–134. https://doi.org/10.1016/j.socscimed.2012.04.012.

Morton, T., van der Bles, A., & Haslam, S. (2017). Seeing our self reflected in the world around us: The role of identity in making (natural) environments restorative. *Journal of Environmental Psychology, 49*, 65–77.

Muthén, L. K., & Muthén, B. O. (2012). *Mplus user's guide* (7th ed.). .

Pasanen, T., Neuvonen, M., & Korpela, K. (2017). The psychology of recent nature visits: (How) are motives and attentional focus related to post-visit restorative experiences, creativity, and emotional well-being? *Environment and Behavior*. https://doi.org/10.1177/0013916517720261.

Pasanen, T., Tyrväinen, L., & Korpela, K. (2014). The relationship between perceived health and physical activity indoors, outdoors in built environments, and outdoors in nature. *Applied Psychology: Health and Well-Being, 6*(3), 324–346. https://doi.org/10.1111/aphw.12031.

Penedo, F., & Dahn, J. (2005). Exercise and well-being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry, 18*(2), 189–193.

Richardson, M., McEwan, K., Maratos, F., & Sheffield, D. (2016). Joy and calm: How an evolutionary functional model of affect regulation informs positive emotions in nature. *Evolutionary Psychological Science, 2*(4), 308–320. https://doi.org/10.1007/s40806-016-0065-5.

Rutkowski, L., & Svetina, D. (2014). Assessing the hypothesis of measurement invariance in the context of large-scale international surveys. *Educational and Psychological Measurement, 74*(1), 31–57. https://doi.org/10.1177/0013164413498257.

Ryan, R., Weinstein, N., Bernstein, J., Brown, K., Mistretta, L., & Gagné, M. (2010). Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology, 30*(2), 159–168. https://doi.org/10.1016/j.jenvp.2009.10.009.

San Juan, C., Subiza-Pérez, M., & Vozmediano, L. (2017). Restoration and the city: The role of public urban squares. *Frontiers in Psychology* doi:810.3389/fpsyg.2017.02093.

Satorra, A., & Bentler, P. M. (2010). Ensuring positiveness of the scaled difference chi-square test statistic. *Psychometrika, 75*(2), 243–248. https://doi.org/10.1007/S11336-009-9135-Y.

Sievänen, T., & Neuvonen, M. (2011). Luonnon virkistyskäytön kysyntä 2010 ja kysynnän muutos [Outdoor recreation demand 2010 and changes in the demand]. In T. Sievänen, & M. Neuvonen (Eds.). *Luonnon virkistyskäyttö 2010 [Outdoor recreation 2010]* (pp. 37–73). Vantaa: Metsäntutkimuslaitos.

Staats, H., Kieviet, A., & Hartig, T. (2003). Where to recover from attentional fatigue: An expectancy-value analysis of environmental preference. *Journal of Environmental Psychology, 23*(2), 147–157.

Stigsdotter, U. K., Corazon, S. S., Sidenius, U., Kristiansen, J., & Grahn, P. (2017). It is not all bad for the grey city – a crossover study on physiological and psychological restoration in a forest and an urban environment. *Health & Place, 46*, 145–154. https://doi.org/10.1016/j.healthplace.2017.05.007.

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M. (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. https://doi.org/10.1021/es102947t.

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. *Human Behavior & Environment: Advances in Theory & Research, 6*, 85–125.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*(3), 201–230. https://doi.org/10.1016/S0272-4944(05)80184-7.

Virtanen, V., Nyberg, R., Salonen, R., Neuvonen, M., & Sievänen, T. (2011). LVVI 2 -seurantatutkimuksen aineisto ja menetelmät [The data and methods of the LVVI2 follow-up survey]. In T. Sievänen, & M. Neuvonen (Eds.). *Luonnon virkistyskäyttö 2010 [Outdoor recreation 2010]* (pp. 19–36). Vantaa: Metsäntutkimuslaitos.

White, M., Pahl, S., Ashbullby, K., Herbert, S., & Depledge, M. (2013). Feelings of restoration from recent nature visits. *Journal of Environmental Psychology, 35*, 40–51. https://doi.org/10.1016/j.jenvp.2013.04.002.

Williams, L., & O'Boyle, E. (2008). Measurement models for linking latent variables and indicators: A review of human resource management research using parcels. *Human Resource Management Review, 18*(4), 233–242. https://doi.org/10.1016/j.hrmr.2008.07.002.

PUBLICATION III

The Psychology of Recent Nature Visits – (How) Are Motives and Attentional Focus Related to Restorative Experiences and Changes in Mood?

Pasanen, T., Neuvonen, M., Korpela, K.

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The Psychology of Recent Nature Visits: (How) Are Motives and Attentional Focus Related to Post-Visit Restorative Experiences, Creativity, and Emotional Well-Being?

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Abstract

The health-enhancing benefits of contact with nature have become widely recognized, but empirical studies that consider the motives and attentional focus of nature visits are lacking. These psychological qualities may partly determine why one visits natural environments and why some visits are more restorative than others. This study examined recent nature visits by Finnish survey respondents (n = 565) via exploratory structural equation modeling. In the estimated models, motives and attentional focus explained 54% to 57% of post-visit restorativeness, 22% of creativity, and 33% to 37% of emotional well-being. Of the assessed motives, stress reduction was most strongly connected to increased restorativeness and emotional well-being. The motive to be alone showed a positive indirect—but negative direct—connection to emotional well-being. In addition, focus on oneself, the activity,

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and the environment were positively associated with the outcomes. The results indicate that motives and attentional focus are strongly connected to the outcomes of nature visits.

Keywords
natural environments, motivation, recreation/leisure, survey research, restorativeness

Introduction

Exposure to nature has been related to restorative experiences and improved well-being in many studies over the past two decades (e.g., Abraham, Sommerhalder, & Abel, 2010; Hartig, Mitchell, de Vries, & Frumkin, 2014; Keniger, Gaston, Irvine, & Fuller, 2013). In these studies, well-being outcomes have varied depending on the research field and design, covering short-term and long-term well-being measures, both psychological and physiological (Hartig et al., 2014). Nature is, in summary, thought to promote stress reduction and overall well-being via three theoretically justified and empirically supported behavioral mechanisms (Abraham et al., 2010; Keniger et al., 2013; see Kuo, 2015 for additional mechanisms): It encourages physical activity (the physical mechanism), it provides a setting for social encounters or for escaping social pressures (the social mechanism), and it contains special qualities that alleviate stress (the stress-reduction mechanism). Although usually explored separately, the mechanisms coincide in many ways and are thus thought to reinforce the benefits associated with one another (Hartig et al., 2014).

The outcomes that nature visits have most consistently been related to include induced restoration and increased positive affect (Hartig et al., 2014; McMahan & Estes, 2015). Repeated positive experiences, in turn, are one plausible explanation for the positive population-level correlations between exposure to green environments and longer-term subjective well-being, such as satisfaction with life (Hartig et al., 2014; Vemuri, Morgan Grove, Wilson, & Burch, 2011). There is tentative evidence that exposure to natural environments additionally enhances vitality, a state of positive activation (Ryan et al., 2010; Thompson Coon et al., 2011). Vitality is theoretically described as a complementary but distinct concept from restoration (Ryan et al., 2010). Vitality refers to "feeling alive" and having positive energy available for oneself, mainly psychologically but also physically (Ryan & Frederick, 1997). Being distinct from deactivated positive states such as contentment, happiness, and satisfaction, it has strong connections to more general positive states such as life satisfaction (Ryan & Frederick, 1997). In this study, vitality

is assessed as an affective outcome of nature visits together with more established measures of restorativeness, positive and negative affect, and life satisfaction.

In addition to restorative and affective benefits, theory and empirical studies suggest that natural environments can improve cognitive and attentional performance (Berman, Jonides, & Kaplan, 2008; Berto, 2005; Kaplan & Kaplan, 1989). Consistent with this perspective, more recent studies have proposed that creativity, as a higher-level executive cognitive function, could likewise be enhanced by exposure to nature (Atchley, Strayer, & Atchley, 2012; Plambech & Konijnendijk van den Bosch, 2015). Nature exposure can also lead to increased creativity via positive affect. An extensive meta-analysis concluded that creativity was systematically associated with activated positive states but not with deactivated positive states (Baas, De Dreu, & Nijstad, 2008). In terms of causality, it seems that positive affect precedes increases in creativity (Baas et al., 2008). As nature experiences have been consistently shown to result in increased positive affect (McMahan & Estes, 2015), it is possible that a more positive state following nature exposure also induces increased creative responses. Accordingly, preliminary empirical evidence implies that exposure to nature can improve several dimensions of a creative process, such as identifying and solving problems and gaining new ideas (Atchley et al., 2012; Ferraro, 2015; Plambech & Konijnendijk van den Bosch, 2015). The evidence on creativity and nature exposure, however, is limited to specific populations (Ferraro, 2015; Plambech & Konijnendijk van den Bosch, 2015). This study contributes to the literature by assessing self-reported creativity as an outcome of nature visits together with restorative and affective measures, as described above.

Previous research has not emphasized everyday nature experiences as a part of individual self- and emotional regulation. It has been suggested that the health-enhancing effects of visiting natural environments are a result of conscious self-regulation where people have learned that natural settings are more likely than others to provide restorative outcomes, such as relaxation and attention restoration (Hartig et al., 2014; Korpela & Ylén, 2007). However, we do not know to what extent the benefits of a nature experience are actually a result of a conscious effort to reduce stress, and to what extent these benefits are an unconsidered side-effect of an activity with another primary purpose, such as socializing or maintaining fitness. Motives play an important role in determining why one chooses to visit natural environments and why some visits are more restorative than others (Knopf, 1987). Four main types of motives for nature visits in particular have been identified: tranquility, social affirmation, competence, and natural stimuli (Knopf, 1987). These motives are present in the three abovementioned behavioral

mechanisms that explain why exposure to nature and well-being are connected, and they are further elaborated in the following sections.

The majority of the environmental well-being literature has focused on the consequences and after-effects of nature visits, and has neglected aspects during environmental experiences that may facilitate restoration, such as attentional focus on the environment (Hartig et al., 2014). The concept of attentional focus in environmental experiences dates back to 1976 when Ittelson, Franck, and O'Hanlon (1976) identified different ways to experience an environment. The underlying idea is that individuals are not passive recipients of their surrounding environment, but they actively modify their environmental experience by choosing what to focus on, and that way, they can achieve their goals (Ittelson et al., 1976).

The main contribution of this study is a quantitative analysis of how different types of motives and attentional foci are connected to perceived outcomes of nature visits. To our knowledge, these components have not been previously studied together. The topic is novel and, consequently, we have taken an exploratory approach to examine it by integrating measures and theories from environmental psychology, cognitive psychology, and leisure studies. These theoretical frameworks are described in the rest of this introduction. First, we present the mechanisms that have been shown to explain the positive relationship between exposure to nature and subjective well-being in more detail. Second, we evaluate the existing evidence regarding motives and attentional focus in nature experiences. Third, we briefly introduce two theories from cognitive psychology that explain the interaction between motives and attentional focus. How these theories are applied in this study is explained in the final section of the introduction where we present the research questions of this study and the conceptual model for examining these questions.

Mechanisms That Explain the Well-Being Effects of Nature Experiences

The physical mechanism. Visiting natural environments is expected to improve well-being by encouraging health-related behavior such as physical activity. Natural settings have also been found to provide added value to the known benefits of exercise (Barton & Pretty, 2010; Bowler, Buyung-Ali, Knight, & Pullin, 2010; Thompson Coon et al., 2011). The motive to be physically active relates to competence building that has been identified as one of the main motives for nature visits (Knopf, 1987).

Experimental studies have consistently shown that exercise in natural settings improves mood and self-esteem within five minutes of exposure (Barton & Pretty, 2010). A meta-analysis by Bowler et al. (2010) concluded that

exercise in nature, compared with built environments indoors or outdoors, improves attentional capacity and reduces negative affect. Similarly, a systematic review by Thompson Coon et al. (2011) found that the benefits following exercise in outdoor environments, compared with similar activities in indoor settings, include decreased negative emotions and increased energy and feelings of revitalization.

The social mechanism. According to the social mechanism, nature is thought to provide a suitable platform for social interaction that promotes well-being (Hartig et al., 2014). Thus, natural environments can be visited for their positive attributes that enable pleasant social contacts. Knopf (1987) has identified this type of pull motive for nature visits as a "quest for social affirmation." In addition, the social mechanism encompasses a push dimension where nature is valued because it is seen as a place for escaping social pressures (Hartig et al., 2014). This push dimension emphasizes the qualities that natural environments do not possess such as social stressors, offering an opportunity to experience tranquility (Knopf, 1987).

Previous empirical research supports both of these dimensions of the social mechanisms. Experimental studies have indicated that being accompanied improves the benefits of walking in urban environments, whereas in natural environments, the benefits are greater for those who walk alone (Johansson, Hartig, & Staats, 2011; Staats & Hartig, 2004). Similarly, in a survey study where the respondents were asked about their recent visit to nature, those who had been accompanied rated their feelings of restorativeness slightly more negatively (White, Pahl, Ashbullby, Herbert, & Depledge, 2013). Moreover, the quality of the green environment may have an impact on social interactions. A survey-based study in Chicago concluded that open green parks in neighborhoods provide social support that, in turn, mitigates stress, whereas dense vegetation directly reduces stress but discourages social relations (Fan, Das, & Chen, 2011).

The stress-reduction mechanism. Stress reduction and reduced attentional fatigue as a result of exposure to natural environments has been extensively covered by two well-known restoration theories. Ulrich's (1983; Ulrich et al., 1991) stress-reduction theory (SRT) suggests that nature reduces both psychological and physiological stress. According to SRT, the initial affective response to an environment, in the form of liking and preference, has a strong influence on the outcomes of nature visits (Ulrich, 1983; Ulrich et al., 1991). As humans are more prone to prefer natural to urban environments, exposure to nature leads to reduced physiological arousal and a more positive emotional state (Ulrich, 1983; Ulrich et al., 1991). Experimental studies have

consistently reported increased positive affect after short-term nature exposure (McMahan & Estes, 2015). In addition, SRT recognizes the role of attention during nature visits. Ulrich (1983) has noted that the initial affective state influences the direction of one's attention during a nature visit, which, in turn, is connected to the outcome of that visit.

Kaplan and Kaplan's (1989) attention-restoration theory (ART) has a more cognitive approach. ART proposes that many environmental qualities that are often present in natural environments induce involuntary attention restoration from mental fatigue (Kaplan & Kaplan, 1989). Kaplan and Kaplan (1989) differentiate between two types of fascination: "hard," effortful fascination that may lead to mental fatigue, and "soft," involuntary fascination that engages without mental effort and, thus, promotes restoration. An environment that can induce restorative experiences is thought to involve four main qualities: a sense of *escape* that enables distance from everyday concerns, *extent* that creates a sense of being in a whole other world, *fascination* that draws one's attention effortlessly and triggers attention recovery, and *compatibility* between the environment and one's current needs (Kaplan & Kaplan, 1989). According to ART, a restorative experience may involve clearing the mind, attentional recovery, and life reflection (Kaplan & Kaplan, 1989). More recent work building on ART has identified creative problem solving as an important but scarcely studied higher-level cognitive function that exposure to natural environments can facilitate (Atchley et al., 2012; Ferraro, 2015).

Even though the restorative experiences described in SRT and ART are distinct, they also overlap (Kaplan, 1995). Thus, the positive outcomes on emotional and cognitive levels, suggested in these theories, are often seen as complementary psychological processes (Bratman, Hamilton, & Daily, 2012).

Motives and Attentional Focus in Nature Experiences

In ART (Kaplan & Kaplan, 1989), motives are included in the concept of compatibility—Exposure to an environment can be restorative if it supports the fulfillment of one's current needs. SRT sees that motives are guided by one's affective state and that they drive behavior (Ulrich, 1983). Indeed, empirical qualitative studies have concluded that motives guide individuals to choose different activities in different types of locations (Irvine, Warber, Devine-Wright, & Gaston, 2013; Kassavou, French, & Chamberlain, 2015). The chosen recreational activities can, in turn, affect an individual's health and well-being (Irvine et al., 2013).

Knopf (1987) synthesized motive-related empirical and theoretical studies from a wide range of disciplines addressing people–environment relationships and identified four main categories of motives for nature visits. The first, *tranquility*, Knopf describes as coping behavior that is focused on escaping from unwanted aspects of everyday life. These so-called push factors can include noise, stimulus overload, and social pressures. *Social affirmation*, the second main motive type, functions as a pull factor, recognizing that natural environments often provide a platform for building or re-enforcing companionship. The third type of motive relates to *competence* such as learning new skills or maintaining fitness. The fourth motive category is *natural stimuli*, implying that natural environments (or their elements) provide a unique experience that is desirable *per se*, and therefore, these nature-related motives are exclusive to nature experiences. It is common for one to have several motives for a single visit to nature, and the motives can derive from different categories and even be in conflict with one another (Knopf, 1987).

Although motives in nature experiences have been well examined in recreation studies (Irvine et al., 2013; Knopf, 1987; Manning, 2010), there is a lack of knowledge about the extent to which the motive is able to affect the outcome of the experience. This is one of the main foci of the present study. A stress management study of United States Coast Guard Academy cadets, assessing all types of restorative activities, addressed this issue and found that most restorative events were associated with motives such as escaping daily routines or role overloads, achievement, teaching or sharing skills, and enjoying nature (Siniscalchi, Kimmel, Couturier, & Murray, 2011). Motives guide not only the choice of activity and environment but also the way the environment is experienced (Ittelson et al., 1976). Although the concept of attention and its recovery is central in ART (Kaplan & Kaplan, 1989), little research has investigated *attentional focus* during nature exposure (Hartig et al., 2014). Ittelson et al. (1976) proposed five modes in which people experience nature: experiencing (a) the physical features of a place, (b) place as part of self and one's identity, (c) social relationships in a place, (d) emotions that the place induces, and (e) place as a setting for a particular action. These modes have been operationalized in experimental leisure studies where people have been asked about their attentional focus during a nature experience. In these empirical analyses, experiencing place as a part of oneself and in terms of the emotions it induces have correlated highly, and thus, four separate foci for environmental experience have been confirmed (Borrie & Roggenbuck, 2001).

In ART, Kaplan and Kaplan (1989) suggest that attention recovery is triggered by involuntary fascination. Although this type of soft fascination is one

important determinant of restoration, more recent evidence indicates that restorative benefits may also follow when people consciously direct their attention to the physical features of the environment such as to a specific restorative element or object (following specific instructions, see Duvall, 2011, 2013; Lin, Tsai, Sullivan, Chang, & Chang, 2014). Therefore, consciously directed attention may potentially facilitate health promotion in everyday nature experiences where convenience and several competing interests drive the choice of setting and activity (Irvine et al., 2013; Kassavou et al., 2015). The present study elaborates further on the topic of attention orientation by asking people to recall what they focused on during the most recent nature visits.

The Relationship Between Motives and Attention

Matching motives and attentional focus. Cognitive psychologists have argued that our motives, which can be affected by our current mental state and previous experiences, influence the direction of our attention. This assumption derives from the so-called New Look of perception, a view that emerged in the 1940s (Erdelyi, 1974; Lindzey, Gilbert, & Fiske, 1998). Although debated, the foundation of the view, stating that perception is dependent on one's internal processes (Erdelyi, 1974), is still prevalent in psychological research (Balcetis & Dunning, 2006, 2007; Lupyan, 2015; Voss & Schwieren, 2015). These internal processes include attitudes, values, expectancies, and needs, and they have been argued to bias all human information processing (Erdelyi, 1974). In the context of environmental psychology, Ittelson et al. (1976) highlighted that the modes in which an environment is experienced are largely determined by one's personal motives for this experience. Drawing from these views, we expect that motives prior to a nature visit direct attentional focus during that visit. For example, those who strongly wish to experience nature will focus on the natural features during their stay. We examine whether motives and attentional focus match in our analysis in a model we call "the restricted model."

Continuous automatic processing. Bargh and Chartrand's (1999) view states that, as in the New Look of perception theory described above, goals guide information processing and behavior. Bargh and Chartrand, however, add that the mechanisms that translate goals into behavior can be automatic and both external (environmental, situational) and internal (conscious motives). Thus, our goals and subsequent behavior might be automatically driven by situational features (Bargh & Chartrand, 1999). People can visit natural environments for nature enjoyment, but if they engage in physical activity

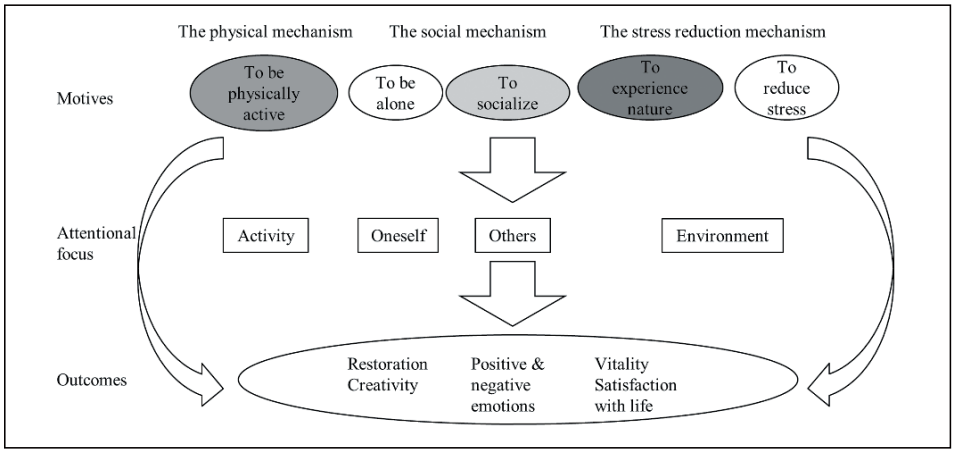

Figure 1. The conceptual model to be tested.
Note. The connections from all motives and attentional foci to all outcomes are estimated. The connections between motives and attentional focus are estimated both within (restricted model) and between the overarching mechanisms (unrestricted model). In the motives, the background color reflects the type of motive (Knopf, 1987): white—escape motives, light gray—social affirmation, gray—competence, dark gray—natural stimuli.

at the same time, the activity can draw their attention away from natural features. Moreover, fascination, one of the main features of ART, presumes that a restorative environment draws one's attention automatically, that is, involuntarily. This soft fascination can occur regardless of one's preceding state of mind and goals. Therefore, attentional focus can be automatically driven by the environment so that motives do not direct focus all the time, but attentional focus can vary. In this study, we test this assumption in a model where all motives for nature visits are assumed to have a connection with all types of attentional focus; we call this model "the unrestricted model."

The Research Problem in the Present Study

We assess the role of motives and attentional focus in explaining the outcomes of nature experiences (Figure 1). We test two structural equation models (SEM) where the relationship between motives and attentional focus is either restricted (Erdelyi, 1974; Ittelson et al., 1976) or unrestricted (Bargh & Chartrand, 1999). Our first research question asks,

> **Research Question 1 (RQ1):** Can motives and attentional focus explain the outcomes of nature visits, and if so, which outcomes are best explained.

We answer this question by evaluating how the models fit empirical data and the explained variance in the outcome measures. Our second research question asks,

Research Question 2 (RQ2): Which of the following factors in particular best explain post-visit outcomes of nature visits:

a. motives to be physically active, to be alone, to socialize, to experience nature, and to reduce stress (independent of attentional focus; RQ2a),
b. attentional focus on the activity, on oneself, on other people, and on the environment (independent of the motives; RQ2b), and
c. combinations of the abovementioned motives and attentional foci (RQ2c).

The measures and the tested SEM, including mediators and both exploratory and confirmatory latent factors, are presented in detail in the next section.

Method

Data and Participants

The survey was a follow-up to the Outdoor Recreation Demand Inventory (LVVI2; explained in more detail in Korpela, Borodulin, Neuvonen, Paronen, & Tyrväinen, 2014), a nationally representative Finnish survey. The follow-up survey questionnaire was sent to all of those 869 LVVI2 respondents who had expressed an interest in participating in a consecutive survey about the well-being and health effects of nature. This follow-up survey was collected in the autumn of 2009. With 565 respondents, the response rate was 65%. The respondents in this follow-up survey were more highly educated than those in the main survey, and the proportion of females was higher. However, regarding the frequency of nature visits (Table 1), there were no differences between the surveys. Almost all (95%) respondents stated that they visit natural environments weekly, and 25% reported visiting nature every day. The respondents resided in rural (15%), suburban (13%), and urban (72%) areas of Finland (Table 1), where the everyman's right guarantees open access to forests and natural environments regardless of land ownership.

The survey asked detailed questions about the typical place or route in nature that the respondents tend to visit and their experiences from their most recent visit there. The respondents had the option to describe a place or an area ($n = 179$), a route ($n = 268$), or the garden of their home or second home ($n = 118$). Depending on this choice, they were also asked different types of

Table 1. Sample Characteristics.

Variable	*n*	Category	Share (%)
Gender	561	Male	39.8
		Female	60.2
Age (years)[a]	564	15-34	23.1
		35-54	46.2
		55-64	21.1
		≥65	9.6
Outdoor recreation frequency[a]	563	Every day	25.4
		4-6 times a week	24.2
		2-3 times a week	33.9
		≤Once a week	16.5
First visit to the recreation area (or route)	557	<1 year ago	9.2
		1-3 years ago	21.0
		≥4-10 years ago	69.9
(Approximate) share of all outdoor recreation in this place/route[a]	560	Only a small	3.4
		A quarter to half	46.1
		Three quarters	33.0
		All or almost all	17.5
Previous visit to the place/route[a]	559	Today	27.7
		Yesterday	20.9
		2-6 days ago	29.5
		≥1 week ago	21.8

Note. [a]Some categories have been combined.

questions about the qualities of these natural environments, but these questions are outside the scope of this study. The place or route described was familiar to the respondents as the majority (70%) had visited it for the first time 4 or more years ago. However, the majority (83%) also reported visiting other outdoor locations for recreational purposes. The respondents had visited the place or route most commonly on the same day (28%) or the day before (21%) they had filled in the questionnaire. The most common type of activity in the place or route was walking (33%) or walking with a dog (20%), followed by gardening (12%) and running/jogging (9%).

Measures

In the following sections, we describe all variables used in the analyses. Their descriptive statistics and bivariate correlations can be found in the supplementary material (Online Appendix A1).

Motives: Independent latent factors. The respondents were instructed to recall the situation prior to their most recent visit to their typical place or route in nature. They were asked to evaluate how important a variety of factors were in their decision to go outdoors on a 4-point rating scale ranging from 1 = *very important* to 4 = *not important at all*. For easier interpretability, the scale was reverse coded in the analysis. The items were derived from recreation experience preference items measuring recreation motivation (Manning, 2010), of which we selected the motives that matched the physical, social, and stress-reduction mechanisms of nature experiences. These motives also represent Knopf's (1987) categorization of motives for nature experiences, described in the "Introduction."

The option "maintaining physical fitness" was the indicator for the motive *to be physically active*, reflecting competence-building (Knopf, 1987) and the physical mechanism of the benefits of contact with nature. The social mechanism included two types of motives, reflecting either escape from interaction (tranquility; Knopf, 1987) or the need for it (social affirmation; Knopf, 1987). The indicator for the motive *to be alone* was "I get to be alone," and the two indicators for the motive *to socialize* were "I can be with friends" and "I can be with family" (r = .59). The motives relating to the restorative mechanism derived from the expected restorative end result, stress reduction, and from the expected means of obtaining it, namely, through experiencing nature. The motives *to reduce stress* (reflecting tranquility; Knopf, 1987) were stated as "I can relax," "I can withdraw from daily routines," and "I can reduce stress" (Cronbach's α = .79). The motives *to experience nature* (reflecting natural stimuli; Knopf, 1987) were phrased "I can enjoy nature" and "I can learn from nature" (r = .70).

Attentional foci: Mediators. The respondents were instructed to recall their experiences during their most recent visit to their typical place or route in nature. They were asked to evaluate to what extent they had focused on "the activity, that is, outdoor recreation" (*focus on the activity*), "your own thoughts and emotions" (*focus on oneself*), "other people around you" (*focus on others*), and "the environment, that is, the natural or urban surroundings" (*focus on the environment*). The scale was a 7-point rating scale ranging from 1 = *completely* to 7 = *not at all*. For easier interpretability, the scale was reverse coded in the analysis. The items represent the main types of attentional focus in environmental experiences (Borrie & Roggenbuck, 2001; McIntyre & Roggenbuck, 1998). We settled for surveying only one item per type of attentional focus in line with the approach by McIntyre and Roggenbuck (1998). Other studies have assessed two or more items per attentional

focus, but their factor structure has not been fully confirmed (Borrie & Roggenbuck, 2001; McKay, Brownlee, & Hallo, 2012).

Post-visit mental states: Latent outcome factors. The respondents were instructed to recall the situation after their most recent visit to their typical place or route in nature. They were asked to evaluate to what extent a number of changes in their mental state had occurred, and to what extent they had felt a number of emotions (see Table 2). The scale used was a 7-point rating scale ranging from "Describes my experience . . ." 1 = *completely* to 7 = *not at all*. For easier interpretability, the scale was reverse coded in the analysis.

The post-visit mental states were measured as restorative experiences (six items from the Restorative Outcome Scale [ROS]; Korpela, Ylén, Tyrväinen, & Silvennoinen, 2008; see also Hartig, Lindblom, & Ovefelt, 1998; Staats, Kieviet, & Hartig, 2003), creativity (four items), negative emotions (eight basic emotions; see Zelenski & Larsen, 2000), positive emotions (three basic emotions; see Zelenski & Larsen, 2000), vitality (two positive items and one negative item from the Subjective Vitality Scale [SVS]; see Ryan & Frederick, 1997), and life satisfaction (one item). Because the respondents reported few negative emotions, these items were highly skewed and peaked, and there was little variance to examine. The negatively phrased items were therefore excluded from the analyses.

Analytic Approach

First, for data analysis, all "Don't know/Cannot say" options were coded as missing. All original rating scales were reverse coded so that higher values indicated greater motivation, greater attentional focus, and a stronger positive post-visit mental state. All analyses were performed using Mplus version 7.4. Many outcome items correlated significantly with each other (see supplementary material [Online Appendix A1]). Consequently, significant cross-loadings between factors were expected, in which case an exploratory, rather than confirmatory, outcome factor structure was chosen based on recommendations by Marsh, Lüdtke, Nagengast, Morin, and Von Davier (2013). First, in the exploratory analysis, the outcome structure was inspected by traditional exploratory factor analysis (EFA) with the default oblique Geomin rotation ($\varepsilon = .01$), which generally produces optimal solutions for new variable structures (Asparouhov & Muthén, 2009). Variables with large residual variances (>.50) were dropped from the analysis one by one, after which the factors that were conceptually sound, with eigenvalues greater than 1, were considered for further analysis (Tabachnick & Fidell, 2007). In the end, the outcome variables formed three latent factors that were conceptually distinct

Table 2. The Exploratory Factor Structure of the Assessed Post-Visit Outcomes in the ESEM Model, With Standardized Estimates and Standard Errors.

Post-visit outcomes of the most recent nature visit	F1 Restorativeness	F2 Creativity	F3 Emotional well-being	Residual variance
I calmed down	**.81** (.03)	−.02 (.03)	.03 (.03)	.32
My concentration and alertness increased	**.94** (.03)	.06 (.02)	−.14 (.04)	.24
I got new spirit for my everyday routines	**.75** (.03)	−.02 (.03)	.13 (.04)	.29
I restored and relaxed	**.84** (.03)	−.07 (.03)	.11 (.03)	.21
I forgot everyday worries	**.62** (.04)	<.01 (.03)	.17 (.04)	.43
My thoughts were clarified	**.77** (.03)	.12 (.03)	.01 (.03)	.32
I came up with many new ideas	−.02 (.04)	**.72** (.03)	.11 (.05)	.43
I got excited about a new idea	−.16 (.05)	**.97** (.02)	.02 (.01)	.15
I figured a solution to a problem that had been bothering me	.08 (.03)	**.89** (.03)	−.21 (.05)	.27
I felt particularly creative after being outdoors	.06 (.04)	**.62** (.03)	.25 (.05)	.38
Happiness	−.03 (.03)	.01 (.02)	**.92** (.03)	.17
Calmness	.20 (.04)	.03 (.03)	**.68** (.03)	.30
Joy	.08 (.04)	.01 (.02)	**.80** (.03)	.26
I felt alive and vital	.18 (.04)	.05 (.03)	**.66** (.03)	.34
I was fairly satisfied with my life	−.05 (.04)	−.02 (.03)	**.76** (.03)	.48
Scale *M* and *SD*	5.27 (0.93)	3.57 (1.38)	5.30 (0.90)	
Correlations between the factors	F1	.23	.54	
	F2		.28	

Note. Oblique Geomin rotation with $\varepsilon = 0.01$. In bold: loadings > 0.40. ESEM = exploratory structural equation modeling.

from one another, although some small but significant cross-loadings were present (Table 2). The items that loaded highly on the first two factors, restorativeness and creativity, were as expected, whereas the third factor was a combination of positive emotions, vitality, and life satisfaction. As the third factor contained positive affective states (both activated and deactivated) and a more general state of being satisfied with one's life, we named the third factor "emotional well-being."

Second, we tested two complete models with independent latent factors and mediators by exploratory structural equation modeling (ESEM): (a) "restricted model" with matching motives and attentional focus and (b) "unrestricted model" with all connections between motives and attentional focus estimated. To answer RQ1 about whether motives and attentional foci can explain the outcomes of nature visits, we evaluated the models based on the χ^2 test, fit indices (the comparative fit index [CFI] and the root mean square error of approximation [RMSEA]), and the percentages of variance explained (R^2) in the outcomes (Kline, 2016). In the ESEM models, the outcome factors were specified as explorative. The independent factors, motives, were confirmatory, and their variances were fixed at 1 (Bollen, 1989). The motives that were measured by only one indicator (motives to be physically active and to be alone) were treated as latent single indicator factors, and their loadings were fixed at .9 to reach mathematical identification in both models (Bollen, 1989). Although applied researchers generally prefer to include several items per factor, using single items is warranted from a methodological point of view and might be even superior over multiple items if the measures are reliable (Hayduk & Littvay, 2012). All ordinal factor indicators were specified as categorical, which meant performing a normal transformation for their values (Muthén & Muthén, 1998-2012). We interpreted standardized estimates because the variables' scales were arbitrary (Yuan & Chan, 2011), and the otherwise recommended bootstrapped standard errors and confidence intervals (Bollen & Stine, 1990) were not available with the ESEM approach (Muthén & Muthén, 1998-2012). The significance of the estimates was determined by the delta method (see below), which is considered accurate in large samples (Bollen & Stine, 1990).

With mediation models such as the one in this study, three types of relationships can be assessed. First, *direct connections* are the traditional regression relationships between an independent factor (or a mediator) and an outcome. We examine direct effects to answer RQ2a and RQ2b (i.e., which motives and attentional foci are directly connected to the outcomes). Second, *indirect connections* evaluate the combined effect of two regression paths: one from the independent factor to a mediator, and another from the mediator to an outcome. Third, *total effect* refers to the combination of direct and indirect effects. Indirect connections and total effects are explored in response to RQ2c (i.e., which combinations of motives and attentional foci are connected to the outcomes). The significances of all these relationships are determined by the delta method, a function of the path estimates and their standard errors (Sobel, 1986). In the simplest case, which is that of direct connections, a path's significance is determined by the ratio of the estimate to its standard error. In the case of large samples, this ratio is assumed to be normally distributed (Bollen

& Stine, 1990). It is worth mentioning that, since we analyze cross-sectional data, the word "effect" does not imply causalities here; instead, "effect" is the generally accepted term in the assessment of mediation models.

Although evaluating the direct, indirect, and total effects multiplies the number of evaluated connections, there are several valid reasons for this thorough comparison. First, these effects are all considered estimates of effect size in mediation models (Fairchild, MacKinnon, Taborga, & Taylor, 2009; Preacher & Kelley, 2011). Second, we are not only interested in the significant individual connections but also in the combinations of motives and mediators that together contribute to the outcomes. Third, total effects provide estimations of the motives that are the strongest correlates of our outcomes, and therefore, their identification is important.

Results

RQ1: Variances Explained and the Overall Model Fit

Our first research question examined how well the models in general are able to explain reported post-visit mental states. The restricted model with matching motives and attentional focus explained 57% of the variation in restorativeness, 22% of the variation in creativity, and 37% of the variation in emotional well-being. The respective figures in the unrestricted model were slightly smaller: 54%, 22%, and 33%. Both models fit the data equally well, with RMSEA = .05 and CFI = .98 for both models, apart from the χ^2 test that rejected both the restricted ($\chi^2 = 664$, $df = 279$, $p < .001$) and the unrestricted model ($\chi^2 = 629$, $df = 266$, $p < .001$). However, the Satorra–Bentler corrected χ^2 test favored the unrestricted model ($\chi^2_{diff} = 42$, $df = 13$, $p = .0001$). As the χ^2 test can be sensitive to sample size (Kline, 2016), we inspected the models' residuals to detect possible sources of misfit (see supplementary material [Online Appendix A1]). If the absolute value of the difference between the observed and estimated correlation exceeds .10, the residual can be considered large (Kline, 2016). In this analysis, 10 out of 378 residuals (2.6%) exceeded this cut-off in the restricted model and 8 (2.1%) in the unrestricted model. The largest residuals were .17 and .13, respectively, which we considered tolerable. We conclude that both models fit the data well, although the residuals were slightly smaller in the unrestricted model, and the variances explained were slightly greater in the restricted model.

In the restricted model, the connections from each motive to the matching attentional focus were significant and conceptually sound (see Figure 2 for an overview, and supplementary material [Online Appendix C1] for the estimates and their standard errors). The unrestricted model showed two additional

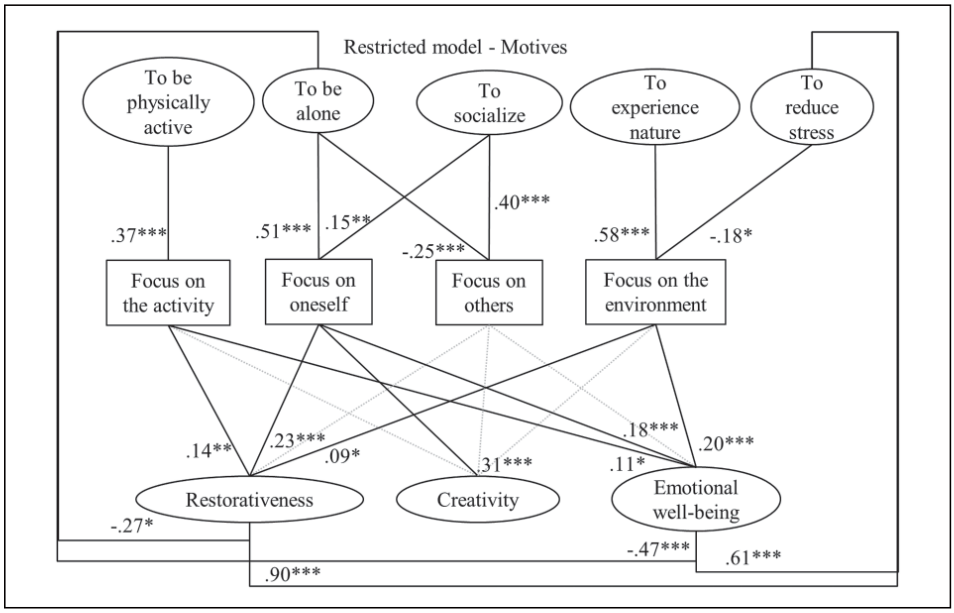

Figure 2. The significant direct paths ($p < .05$; solid lines) of the restricted model ($n = 565$; see supplementary material [Online Appendices C1, C2, and C3] for all path estimates and their *SE*s). The latent variables are shown in ellipses and nonsignificant paths in dashed gray lines. For readability, the indicators of the latent variables (Online Appendix B1), covariances, and residual correlations (Online Appendix D1) are not shown, but they are provided as supplementary material. *$p < .05$. **$p < .01$. ***$p < .001$.

mismatching connections between a motive and attentional focus. Motive to socialize was connected to increased focus on the activity, and the motive to reduce stress was connected to increased focus on oneself (Figure 3).

In both models, all latent independent factors (motives) covaried. Similarly, the residual covariances between all attentional foci were estimated. For readability, the above covariances are not shown in the figures, but their estimates are provided in the supplementary material (Online Appendix D1).

RQ2a: Motives and the Outcomes of Nature Visits (Direct Connections)

There were only a few significant direct connections between the motives and the outcomes after controlling for attentional foci, but these few connections were strong in effect size. First, motive to be alone was negatively connected to emotional well-being (Figure 2, Figure 3) in both models, and to

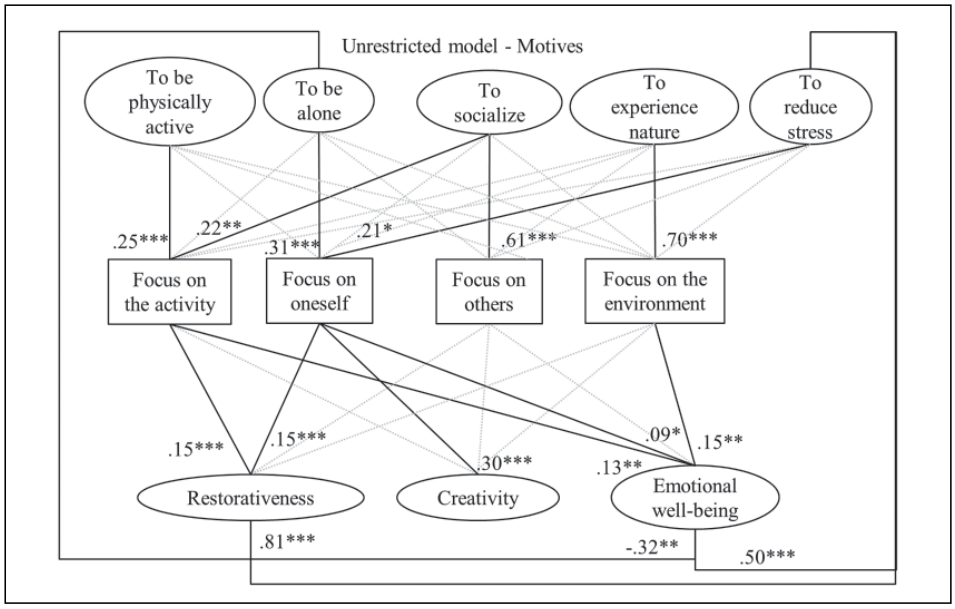

Figure 3. The significant direct paths ($p < .05$; solid lines) of the unrestricted model ($n = 565$; see supplementary material [Online Appendices C1, C2, and C3] for all path estimates and their *SE*s). The latent variables are shown in ellipses and nonsignificant paths in dashed gray lines. For readability, the indicators of the latent variables (Online Appendix B1), covariances, and residual correlations (Online Appendix D1) are not shown, but they are provided as supplementary material. *$p < .05$. **$p < .01$. ***$p < .001$.

restorativeness in the restricted model. Second, the motive to reduce stress had a strong positive direct connection to emotional well-being and restorativeness in both models. Other motives were not directly related to any of the outcomes.

RQ2b: Attentional Foci and the Outcomes of Nature Visits (Direct Connections)

All attentional foci, except for focusing on other people, showed some positive connections to the outcomes. Focus on oneself was most strongly and positively connected to the outcomes of nature visits, as it was connected to all outcomes in both models (Figure 2, Figure 3). In addition, both models showed positive connections between focus on the activity and greater restorativeness and emotional well-being, and between focus on the environment and emotional well-being. In addition, in the restricted model, focus on the environment was associated with increased restorativeness (Figure 2).

Table 3. Standardized Significant Indirect Connections From the Independent Factors to the Outcome Factors in the Restricted and Unrestricted Models.

Model	Motive	Attentional focus	Outcome	Std. indirect effect	*SE*
Restricted	To be physically active	Activity	Restorativeness	.05**	.02
			Emotional well-being	.04*	.02
	To be alone	Oneself	Restorativeness	.12***	.02
			Creativity	.16***	.03
			Emotional well-being	.09***	.03
	To socialize	Oneself	Restorativeness	.03**	.01
			Creativity	.05**	.02
			Emotional well-being	.03*	.01
	To experience nature	Environment	Emotional well-being	.11***	.03
Unrestricted	To be physically active	Activity	Restorativeness	.04*	.01
			Emotional well-being	.03*	.01
	To be alone	Oneself	Restorativeness	.05*	.02
			Creativity	.09**	.03
	To socialize	Activity	Restorativeness	.03*	.02
	To reduce stress	Oneself	Restorativeness	.03*	.01
			Creativity	.06*	.03
	To experience nature	Environment	Emotional well-being	.10**	.04

*$p < .05$. **$p < .01$. ***$p < .001$.

RQ2c: Combinations of Motives and Attentional Foci and the Outcomes of Nature Visit (Indirect Connections and Total Effects)

All motives had significant indirect positive connections to at least one outcome, and these indirect connections were relatively low in effect size (.03-.16; Table 3). Only some motives showed significant total effects (sum of the direct and all indirect connections) to an outcome, and these total effects were larger (.19-.88; Table 4).

The motive to reduce stress showed the strongest total effect on the outcomes. It had a positive total effect on restorativeness and emotional well-being in both models (Table 4). In the unrestricted model, the motive to reduce stress had additional positive indirect effects on restorativeness and creativity via focus on oneself (Table 3).

The motive to be alone also showed a total effect on an outcome. This motive was negatively connected to emotional well-being (Table 4), which

Table 4. Standardized Total Effects and Their Standard Errors From the Motives to the Outcomes.

		Restorativeness	Creativity	Emotional well-being
Restricted	To be physically active	−.02 (.06)	−.01 (.07)	.12 (.07)
	To be alone	−.15 (.10)	.05 (.11)	−.40** (.12)
	To socialize	−.12 (.09)	.07 (.09)	−.17 (.10)
	To reduce stress	.88*** (.13)	.15 (.14)	.57*** (.13)
	To experience nature	−.08 (.09)	.19* (.10)	.16 (.09)
Unrestricted	To be physically active	−.3 (.06)	.01 (.07)	.10 (.07)
	To be alone	−.08 (.09)	.05 (.10)	−.31** (.11)
	To socialize	−.08 (.09)	.06 (.09)	−.14 (.10)
	To reduce stress	.83*** (.11)	.15 (.13)	.50*** (.11)
	To experience nature	−.07 (.10)	.19 (.11)	.20 (.11)

*$p < .05$. **$p < .01$. ***$p < .001$.

follows from the strong, negative direct connection between motive to be alone and emotional well-being (RQ2a). In contrast, motive to be alone showed positive indirect connections to almost all of the outcomes: Via increased focus on oneself, it was connected to enhanced restorativeness and creativity in both models, and to increased emotional well-being in the restricted model (Table 3).

The motive to experience nature was the third motive that had a total effect on an outcome. Those who wished to experience nature reported more creativity (but only in the restricted model; Table 4), even though none of the direct or indirect effects on creativity were significant on their own (Figure 2, Table 3). In addition, the motive to experience nature was indirectly and positively connected to emotional well-being via focus on the environment in both models (Table 3).

The motives to be physically active and to socialize had no total effects on the outcomes (Table 4). Yet, they both showed positive indirect connections that were small in effect size (Table 3). The motive to be physically active was indirectly connected to greater restorativeness and emotional well-being via increased focus on the activity in both models. The motive to socialize was indirectly connected to enhanced restorativeness in both models: In the restricted model, this indirect connection was mediated by

focus on oneself, and in the unrestricted model by focus on the activity (Table 3). In addition, motive to socialize was positively connected to creativity and emotional well-being via focus on oneself in the restricted model.

Discussion

Overall, the outcomes of nature visits were well explained by motives and attentional focus during the visit. Of all the outcome factors assessed, the models explained the greatest amount of variance for restorativeness, which indicates that the assessed motives and attentional foci are especially relevant in terms of experienced psychological restoration. Together with the result that positive states were common after the nature visit and negative emotions rarely experienced, these findings complement previous empirical studies that have shown positive associations between exposure to nature and increased positive affect (Barton & Pretty, 2010; McMahan & Estes, 2015), and suggest that motives and attention play an important role in this relationship.

Both types of relationships between motives and attentional focus received empirical support. On the one hand, the restricted model where the motives matched the attentional focus (e.g., the motive to be physically active matched with focus on the activity) showed good fit with the data. Motives were also positively connected to the respective attentional focus in the unrestricted model where their connections to all other attentional foci were additionally evaluated. On the other hand, the unrestricted model was favored by the χ^2 difference test, suggesting that at least some motives were connected to attentional foci that they were not originally matched with. Only two of these "mismatching" connections were statistically significant. Overall, it seems that recalled motives for nature visits are connected to recalled attentional focus during the visit, but the focus can shift during the experience.

Evidence Regarding Motives and Attentional Focus in Relation to Outcomes of Nature Visits

The motives that explained the post-visit outcomes most strongly—to reduce stress and to be alone—both represented Knopf's (1987) push mechanisms. Interestingly, their connections with the outcomes were contrasting. Those who wanted to reduce stress reported the strongest positive outcomes, whereas those who wished to escape social relationships experienced more negative emotional well-being, although the effect was smaller. Several interconnected reasons can explain the strong direct relationship between the

motive to reduce stress and enhanced restorativeness and emotional well-being. From the perspective of the questionnaire, the stress-reduction motive best matched the assessed outcomes (compared with the other motives), as positive changes in one's state of mind are relevant aspects of reduced mental stress. Furthermore, stressed individuals are more likely to visit natural environments for relaxation and stress-reduction purposes than those who are nonstressed (Stigsdotter & Grahn, 2011). Individuals with higher initial levels of stress have a greater potential for restoration and recovery, which, as our results suggest, can be actualized to a large extent in natural environments. Using a place or an environment for self-regulation has been proposed in favorite place studies (Korpela & Ylén, 2007). It is possible that this type of conscious self-regulation applies to the respondents of this study, who described a visit to a familiar place or route in nature. The unrestricted model showed that only a small part of the relationship between the motive to reduce stress and restorativeness was explained by increased focus on one's own thoughts and emotions.

With regard to the motive to be alone, this push mechanism from social relationships appears twofold: Directly, it was connected to lower positive emotional well-being, whereas indirectly, via increased focus on one's own thoughts, it was consistently associated with a more positive post-visit mental state. In the case of emotional well-being, the negative direct connection even outweighed the positive indirect connection, and, overall, those who had wished to be alone experienced lower emotional well-being.

There are a number of plausible but, at this point, speculative explanations for this strongly negative relationship. In terms of causalities, it is possible that either wishing to be alone decreases one's emotional well-being, or that those who already felt depressed sought nature for social withdrawal, and the experience did not improve their emotional well-being. Alternatively, the negative correlation between the motive to be alone and emotional well-being could be due to other underlying factors such as personality differences, or situational factors such as the presence of other people that prevented some respondents from being alone. On the other hand, the result that the motive to be alone was indirectly positively connected to all outcomes via focusing on one's own thoughts and emotions suggests that the focus on oneself was more likely a form of constructive cognitive reappraisal or reflection (Gross & John, 2003) than rumination (Bratman, Hamilton, Hahn, Daily, & Gross, 2015). Previous research supports this view, as visits to natural environments have been found to both reduce rumination (Bratman et al., 2015) and induce deep, restorative reflection on one's life (Herzog, Black, Fountaine, & Knotts, 1997; Kaplan & Kaplan, 1989; Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009).

The motives that we theoretically associated with the restoration theories (to experience nature and to reduce stress) were both relevant in terms of the outcomes. Thus, the results support the view by Hartig et al. (2014) that explains nature's stress-reducing potential through both the absence of stressors and its positive restorative qualities. Similar results were found in the study by Siniscalchi et al. (2011) where motives to enjoy nature and to escape daily routines were both related to restorative experiences. Our results suggest that these motives function differently: The stress-reducing, push motives function independent of attentional focus (see discussion above), whereas the nature-experiencing motive functions indirectly via increased focus on the natural environment. It seems that for those whose motive is to experience nature, focus on the environment is needed for a more positive experience. Whether this focus is due to soft, involuntary fascination (Kaplan & Kaplan, 1989) or a more conscious, directed focus on the natural elements (Duvall, 2011, 2013; Y. Lin et al., 2014) cannot be confirmed at this point. We return to this discussion at the end of this section.

The motives for social affirmation and physical activity were weakly and indirectly associated with the outcomes. In relation to social affirmation, a more positive outcome seems to be connected to the opportunity to focus on oneself or on the activity but, interestingly, not on other people. Thus, social relationships experienced during nature visits may promote gaining a new perspective on oneself or one's life, which facilitates better emotional well-being, creativity, and restorativeness. The restorative and emotional outcome of having a stronger motive for physical activity was, on the contrary, mediated through focusing on the activity. Although the effect was small, this result agrees with the well-known positive connection between physical activity and mental well-being (e.g., Penedo & Dahn, 2005) even though it is contradictory to the results by Siniscalchi et al. (2011). It would have been interesting to test how physical strain functions in this relationship, but unfortunately, we did not measure this.

Regarding attentional focus during nature visits, focusing more on the activity, oneself, or the surrounding environment (but not on other people) were related to positive outcomes. Similarly, in Duvall's (2011) study, engagement during a nature visit produced well-being effects even though the focus of engagement was not specified. It seems that a positive nature experience can result from focusing on a variety of matters, excluding other people. Even though focusing on other people might not be detrimental, the presence of others can deplete attentional resources from other, more restorative, objects of focus such as the surrounding environment (Staats & Hartig, 2004; however, see Duvall, 2013 for contrasting results). Those who are alone are able to direct their full attention to anything they wish, which may

be more likely to lead to an enhanced mood. Alternatively, the scope of attentional focus could be interpreted from the reverse causal order in the light of the "broadening hypothesis," which suggests that a positive state broadens the scope of attention (Fredrickson & Branigan, 2005). In the context of this study, the broadening hypothesis would mean that the connections between positive post-visit mental states and focusing more on the activity, oneself, and the environment were detected because those who were feeling good to begin with simply focused on a broader range of matters.

Finally, it is not known whether our item for environmental focus measured soft, involuntary fascination or consciously directed focus on the environment. It seems plausible, however, that this item better indicates directed, rather than automatic focus for two reasons. First, the only motive that focusing on the environment was connected to was the motive to experience nature. This result implies that when the other motives were more salient, either the respondents' attentional focus did not shift into the environment as a result of fascination, or that fascination cannot be captured by this type of self-reported question. Fascination may be a more subtle, underlying feature of nature visits, whereas recalled attention orientation is a conscious, voluntary attentional focus. Second, focus on the environment was more strongly connected to emotional well-being than to restorativeness, even though restorativeness is an outcome derived from ART. If recalled attentional focus on the environment was an indicator of soft fascination, stronger connection to restorativeness would be expected. Instead, supporting findings by Y. Lin et al. (2014), our results suggest that restoration can be experienced even without recalled focus on the environment.

Limitations

We have identified several limitations of this study. First, the sample was not a random sample of the Finnish population. Survey participation did not presume interest in nature, but the background information (Table 1) implies that most were enthusiastic visitors to nature. These figures did not, however, differ significantly from the average national rates of weekly nature visits (Sievänen & Neuvonen, 2011). Furthermore, access to nature in Finland is high as most people live within a walking distance of a natural environment (Sievänen & Neuvonen, 2011). Therefore, the results of this study may only apply to those who have a good access to natural environments and visit natural environments on a regular basis.

Second, the data were collected at one point in time, and thus the results cannot be interpreted in terms of causalities. Even though the mediational model we tested reflected the causal order of the nature experience—motives

prior to exposure were regressed on attention *during* the experience, which were both regressed on the *post-visit mental states*—the causal order of the relationships may just as well have been the reverse because the experiences were based on memories.

Third, human memory is known to produce bias (Cooper, 1998). We assessed potential systematic memory bias in the initial screening of the data by correlating all the analyzed measures with the length of time between the reported visits and the replies. Only two significant correlations were found, and they were both small. Thus, we considered it safe to assume that the memory-based responses were relatively unbiased by time. Had the data been collected during on-site nature experiences, the responses may have been more objective (Wirtz, Kruger, Napa Scollon, & Diener, 2003), but at the same time, the experiences may have lacked authenticity due to the awareness of being recorded (Stewart & Hull, 1996). The advantage of this type of cross-sectional survey design is that we can conclude that the reported nature experiences were not affected by such bias.

Fourth, one could argue that as the reported experiences were from a familiar place or route, it is difficult to know whether the responses have actually been based on the most recent visit or the recollection of an "average visit" to the location. To minimize this risk, respondents were repeatedly instructed to reply based on their previous visit to the typical place or route. In addition, to assess potential bias caused by more trait- than state-based responses, we examined correlations between all analyzed measures and the familiarity of the route or place, measured by the time passed since the first visit there. No correlations between familiarity and the measures were found, which means that the respondents replied similarly regardless of how familiar they were with the place or route.

Conclusion and Directions for Future Research

Overall, motives and attentional focus both seem to be important aspects of nature visits, as they explain a major share of the outcomes of visiting natural environments. While greater nature relatedness may increase the amount of time spent in green environments (Lin, Fuller, Bush, Gaston, & Shanahan, 2014), one of the main results of this study is that the well-being benefits of nature experiences appear to be related to a much broader range of motives and attentional foci. The motive to reduce stress seems especially strongly related to restorative experiences and positive post-visit mental states, suggesting that the benefits of a nature experience could actually be the result of a conscious effort to reduce stress. Motives for physical fitness, being alone, and experiencing nature appear to match attentional foci while in nature,

which, in turn, is connected to greater restoration and emotional well-being after the visit. Creativity, as a high-level cognitive function, seems mainly connected to focusing on one's own thoughts and emotions. The motives we assessed in this study were limited, so it is possible that other motives are also important in terms of these outcomes.

This research has raised many questions that require further investigation. The study focused on mainly enthusiastic visitors to nature who described a place they had a tendency to visit. More research efforts on the generalizability of the results are required, especially regarding those with limited access and/or low interest to visit nature. We know that motives influence the type of environment that one chooses to visit (Irvine et al., 2013; Kassavou et al., 2015), but whether (and how) environmental qualities influence how attention is directed during nature visits is another interesting topic that merits further research. In addition, causalities regarding well-being mechanisms in nature experiences remain a matter for future studies. Positive mood has been identified as a consistent benefit of nature exposure (McMahan & Estes, 2015), and it could underlie both enhanced creativity (Baas et al., 2008) and a broadened range of attentional focus (Fredrickson & Branigan, 2005). Regarding causalities and the role of attentional focus, tentative evidence shows that purposeful attention direction while exposed to nature facilitates attentional functioning (Duvall, 2011; Y. Lin et al., 2014). If the positive post-visit mental states are even partly the result of optimally directed attention, the well-being effects of nature experiences could be enhanced by conscious efforts to direct attention for people who visit natural environments regularly.

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References

Abraham, A., Sommerhalder, K., & Abel, T. (2010). Landscape and well-being: A scoping study on the health-promoting impact of outdoor environments. *International Journal of Public Health*, *55*, 59-69. doi:10.1007/s00038-009-0069-z

Asparouhov, T., & Muthén, B. (2009). Exploratory structural equation modeling. *Structural Equation Modeling: A Multidisciplinary Journal*, *16*, 397-438. doi:10.1080/10705510903008204

Atchley, R. A., Strayer, D. L., & Atchley, P. (2012). Creativity in the wild: Improving creative reasoning through immersion in natural settings. *PLoS ONE*, *7*, e51474.

Baas, M., De Dreu, C. K. W., & Nijstad, B. A. (2008). A meta-analysis of 25 years of mood-creativity research: Hedonic tone, activation, or regulatory focus? *Psychological Bulletin*, *134*, 779-806. doi:10.1037/a0012815

Balcetis, E., & Dunning, D. (2006). See what you want to see: Motivational influences on visual perception. *Journal of Personality and Social Psychology*, *91*, 612-625. doi:10.1037/0022-3514.91.4.612

Balcetis, E., & Dunning, D. (2007). Cognitive dissonance and the perception of natural environments. *Psychological Science*, *18*, 917-921. doi:10.1111/j.1467-9280.2007.02000.x

Bargh, J. A., & Chartrand, T. L. (1999). The unbearable automaticity of being. *American Psychologist*, *54*, 462-479.

Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science & Technology*, *44*, 3947-3955. doi:10.1021/es903183r

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

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

Bollen, K. A. (1989). *Structural equations with latent variables*. New York, NY: Wiley.

Bollen, K. A., & Stine, R. (1990). Direct and indirect effects: Classical and bootstrap estimates of variability. *Sociological Methodology*, *20*, 15-140.

Borrie, W. T., & Roggenbuck, J. W. (2001). The dynamic, emergent, and multi-phasic nature of on-site wilderness experiences. *Journal of Leisure Research*, *33*, 202-228.

Bowler, D. E., Buyung-Ali, L., 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*, 456-465. 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*, 118-136. doi:10.1111/j.1749-6632.2011.06400.x

Bratman, G. N., Hamilton, J. P., Hahn, K. S., Daily, G. C., & Gross, J. J. (2015). Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proceedings of the National Academy of Sciences*, *112*, 8567-8572. doi:10.1073/pnas.1510459112

Cooper, C. (1998). *Individual differences*. London, England: Arnold.

Duvall, J. (2011). Enhancing the benefits of outdoor walking with cognitive engagement strategies. *Journal of Environmental Psychology*, *31*, 27-35. doi:10.1080/02699930441000238

Duvall, J. (2013). Using engagement-based strategies to alter perceptions of the walking environment. *Environment and Behavior*, *45*, 303-322. doi:10.1177/0013916511423808

Erdelyi, M. H. (1974). A new look at the new look: Perceptual defense and vigilance. *Psychological Review*, *81*, 1-25.

Fairchild, A. J., MacKinnon, D. P., Taborga, M. P., & Taylor, A. B. (2009). R2 effect-size measures for mediation analysis. *Behavior Research Methods*, *41*, 486-498. doi:10.3758/BRM.41.2.486

Fan, Y., Das, K. V., & Chen, Q. (2011). Neighborhood green, social support, physical activity, and stress: Assessing the cumulative impact. *Health & Place*, *17*, 1202-1211. doi:10.1016/j.healthplace.2011.08.008

Ferraro, F. M., III. (2015). Enhancement of convergent creativity following a multi-day wilderness experience. *Ecopsychology*, *7*, 7-11.

Fredrickson, B. L., & Branigan, C. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition and Emotion*, *19*, 313-332. doi:10.1080/02699930441000238

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*, 348-362. doi:10.1037/0022-3514.85.2.348

Hartig, T., Lindblom, K., & Ovefelt, K. (1998). The home and near-home area offer restoration opportunities differentiated by gender. *Scandinavian Housing and Planning Research*, *15*, 283-296.

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health*, *35*, 207-228. doi:10.1146/annurev-publhealth-032013-182443

Hayduk, L., & Littvay, L. (2012). Should researchers use single indicators, best indicators, or multiple indicators in structural equation models? *BMC Medical Research Methodology*, *12*, 159.

Herzog, T. R., Black, A. M., Fountaine, K. A., & Knotts, D. J. (1997). Reflection and attentional recovery as distinctive benefits of restorative environments. *Journal of Environmental Psychology*, *17*, 165-170.

Irvine, K., Warber, S., Devine-Wright, P., & Gaston, K. (2013). Understanding urban green space as a health resource: A qualitative comparison of visit motivation

and derived effects among park users in Sheffield, UK. *International Journal of Environmental Research and Public Health*, *10*, 417-442. doi:10.3390/ijerph10010417

Ittelson, W. H., Franck, K. A., & O'Hanlon, T. J. (1976). The nature of environmental experience. In S. Wapner, S. B. Cohen, & B. Kaplan (Eds.), *Experiencing the environment* (pp. 187-206). New York, NY: Plenum Press.

Johansson, M., Hartig, T., & Staats, H. (2011). Psychological benefits of walking: Moderation by company and outdoor environment. *Applied Psychology: Health and Well-Being*, *3*, 261-280. doi:10.1111/j.1758-0854.2011.01051.x

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

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

Kassavou, A., French, D. P., & Chamberlain, K. (2015). How do environmental factors influence walking in groups? A walk-along study. *Journal of Health Psychology*, *20*, 1328-1339. doi:10.1177/1359105313511839

Keniger, L. E., Gaston, K. J., Irvine, K. N., & Fuller, R. A. (2013). What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health*, *10*, 913-935. doi:10.3390/ijerph10030913

Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). New York, NY: Guilford Press.

Knopf, R. C. (1987). Human behavior, cognition, and affect in the natural environment. In D. Stokols & I. Altman (Eds.), *Handbook of environmental psychology* (Vol. 1, pp. 783-825). New York, NY: Wiley.

Korpela, K. M., Borodulin, K., Neuvonen, M., Paronen, O., & Tyrväinen, L. (2014). Analyzing the mediators between nature-based outdoor recreation and emotional well-being. *Journal of Environmental Psychology*, *37*, 1-7. doi:10.1016/j.jenvp.2013.11.003

Korpela, K. M., & Ylén, M. (2007). Perceived health is associated with visiting natural favourite places in the vicinity. *Health & Place*, *13*, 138-151.

Korpela, K. M., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2008). Determinants of restorative experiences in everyday favorite places. *Health & Place*, *14*, 636-652. doi:10.1016/j.healthplace.2007.10.008

Kuo, M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Frontiers in Psychology*, *6*, 1093. doi:10.3389/fpsyg.2015.01093

Lin, B. B., Fuller, R. A., Bush, R., Gaston, K. J., & Shanahan, D. F. (2014). Opportunity or orientation? Who uses urban parks and why. *PLoS ONE*, *9*, e87422. doi:10.1371/journal.pone.0087422

Lin, Y., Tsai, C., Sullivan, W. C., Chang, P., & Chang, C. (2014). Does awareness effect the restorative function and perception of street trees? *Frontiers in Psychology*, *5*, 906. doi:10.3389/fpsyg.2014.00906

Lindzey, G., Gilbert, D., & Fiske, S. T. (1998). *The handbook of social psychology*. Oxford, UK: Oxford University Press.

Lupyan, G. (2015). Object knowledge changes visual appearance: Semantic effects on color afterimages. *Acta Psychologica*, *161*, 117-130. doi:10.1016/j.actpsy.2015.08.006

Manning, R. E. (2010). *Studies in outdoor recreation. Search and research for satisfaction* (3rd ed.). Corvallis: Oregon State University Press.

Marsh, H. W., Lüdtke, O., Nagengast, B., Morin, A. J., & Von Davier, M. (2013). Why item parcels are (almost) never appropriate: Two wrongs do not make a right—Camouflaging misspecification with item parcels in CFA models. *Psychological Methods*, *18*, 257-284. doi:10.1037/a0032773

Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why is nature beneficial? The role of connectedness to nature. *Environment and Behavior*, *41*, 607-643. doi:10.1177/0013916508319745

McIntyre, N., & Roggenbuck, J. (1998). Nature/person transactions during an outdoor adventure experience: A multi-phasic analysis. *Journal of Leisure Research*, *30*, 401-422.

McKay, A. D., Brownlee, M. T. J., & Hallo, J. C. (2012). Changes in visitors' environmental focus during an appreciative recreation experience. *Journal of Leisure Research*, *44*, 179-200.

McMahan, E. A., & Estes, D. (2015). The effect of contact with natural environments on positive and negative affect: A meta-analysis. *The Journal of Positive Psychology*, *10*, 507-519. doi:10.1080/17439760.2014.994224

Muthén, L. K., & Muthén, B. O. (1998-2012). *Mplus user's guide* (7th ed.). Los Angeles, CA: Author.

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, *18*, 189-193.

Plambech, T., & Konijnendijk van den Bosch, C. C. (2015). The impact of nature on creativity—A study among Danish creative professionals. *Urban Forestry & Urban Greening*, *14*, 255-263. doi:10.1016/j.ufug.2015.02.006

Preacher, K. J., & Kelley, K. (2011). Effect size measures for mediation models: Quantitative strategies for communicating indirect effects. *Psychological Methods*, *16*, 93-115. doi:10.1037/a0022658

Ryan, R. M., & Frederick, C. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality*, *65*, 529-565. doi:10.1111/1467-6494.ep9710314567

Ryan, R. M., Weinstein, N., Bernstein, J., Brown, K. W., Mistretta, L., & Gagné, M. (2010). Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology*, *30*, 159-168. doi:10.1016/j.jenvp.2009.10.009

Sievänen, T., & Neuvonen, M. (2011). Luonnon virkistyskäytön kysyntä 2010 ja kysynnän muutos [Outdoor recreation demand 2010 and changes in the demand]. In T. Sievänen & M. Neuvonen (Eds.), *Luonnon virkistyskäyttö 2010* [Outdoor recreation 2010] (pp. 37-73, Working Papers of the Finnish Forest Research Institute No. 212). Vantaa, Finland: Metsäntutkimuslaitos.

Siniscalchi, J. M., Kimmel, K. D., Couturier, L. E., & Murray, R. (2011). Stress management and the motives of restorative events at the United States Coast

Guard Academy. *Military Psychology*, *23*, 332-349. doi:10.1080/08995605.2011.570601

Sobel, M. E. (1986). Some new results on indirect effects and their standard errors in covariance structure models. *Sociological Methodology*, *16*, 159-186.

Staats, H., & Hartig, T. (2004). Alone or with a friend: A social context for psychological restoration and environmental preferences. *Journal of Environmental Psychology*, *24*, 199-211. doi:10.1016/j.jenvp.2003.12.005

Staats, H., Kieviet, A., & Hartig, T. (2003). Where to recover from attentional fatigue: An expectancy-value analysis of environmental preference. *Journal of Environmental Psychology*, *23*, 147-157.

Stewart, W. P., & Hull, R. B. (1996). Capturing the moments: Concerns of in situ leisure research. *Journal of Travel & Tourism Marketing*, *5*, 3-20.

Stigsdotter, U. K., & Grahn, P. (2011). Stressed individuals' preferences for activities and environmental characteristics in green spaces. *Urban Forestry & Urban Greening*, *10*, 295-304. doi:10.1016/j.ufug.2011.07.001

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston MA: Pearson Education.

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*, 1761-1772. doi:10.1021/es102947t

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. *Human Behavior and Environment: Advances in Theory and Research*, *6*, 85-125.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, *11*, 201-230. doi:10.1016/S0272-4944(05)80184-7

Vemuri, A. W., Morgan Grove, J., Wilson, M. A., & Burch, W. R. (2011). A tale of two scales: Evaluating the relationship among life satisfaction, social capital, income, and the natural environment at individual and neighborhood levels in metropolitan Baltimore. *Environment and Behavior*, *43*, 3-25. doi:10.1177/0013916509338551

Voss, A., & Schwieren, C. (2015). The dynamics of motivated perception: Effects of control and status on the perception of ambivalent stimuli. *Cognition and Emotion*, *29*, 1411-1423. doi:10.1080/02699931.2014.984660

White, M. P., Pahl, S., Ashbullby, K., Herbert, S., & Depledge, M. H. (2013). Feelings of restoration from recent nature visits. *Journal of Environmental Psychology*, *35*, 40-51. doi:10.1016/j.jenvp.2013.04.002

Wirtz, D., Kruger, J., Napa Scollon, C., & Diener, E. (2003). What to do on spring break? The role of predicted, on-line, and remembered experience in future choice. *Psychological Science*, *14*, 520-524. doi:10.1111/1467-9280.03455

Yuan, K., & Chan, W. (2011). Biases and standard errors of standardized regression coefficients. *Psychometrika*, *76*, 670-690. doi:10.1007/S11336-011-9224-6

Zelenski, J. M., & Larsen, R. J. (2000). The distribution of basic emotions in everyday life: A state and trait perspective from experience sampling data. *Journal of Research in Personality*, *34*, 178-197. doi:10.1006/jrpe.1999.2275

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PUBLICATION IV

Can Nature Walks with Psychological Tasks Improve Mood, Self-Reported Restoration, and Sustained Attention? Results from Two Experimental Field Studies

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Can Nature Walks With Psychological Tasks Improve Mood, Self-Reported Restoration, and Sustained Attention? Results From Two Experimental Field Studies

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The evidence for restorative effects of contact with nature is vast. Drawing from two well-known theories in Environmental Psychology, Stress reduction theory and Attention restoration theory, restoration can be seen as a sequential, interactive process that begins with physiological relaxation and results in affective and attention restoration and broader life reflection. This interaction between a person and their environment may be facilitated by actively engaging with the environment but this has been understudied. We examined engagement with the environment by asking participants to complete psychological, restoration theory-driven tasks designed to enhance physiological, affective and attention restoration, while walking on nature trails. We conducted two experimental field studies (conceptual replications) in Finland in a coniferous forest (Study 1; n = 128) and an urban park (Study 2; n = 121). The participants walked at their own pace for 4–6 km with or without psychological tasks. Those in the task conditions completed either theory-based restoration-enhancement tasks or alternative tasks that we expected to be less restorative (Study 1: the same tasks in the reverse order; Study 2: awareness-enhancement tasks). The participants completed self-reports on valence, activation, and restoration, and the Sustained Attention to Response Task, before, and after, the walk. We compared the change between measurements using regression models grouped by study conditions, with age, recent stress, difficulties with wayfinding, start time, and navigation method (Study 2 only) as covariates. Valence and self-reported restoration improved after the walk, but there was no additional benefit from the psychological tasks. In both studies, sustained attention consistently improved following different versions of the restoration-enhancement tasks and, to some extent, after a walk without the tasks. Participants who were more stressed experienced greater improvements in valence and self-reported restoration (Study 1) and sustained attention (Study 2). The results support both Stress reduction theory and Attention restoration theory, and imply that some forms of active engagement with the environment can aid

sustained attention but not affective restoration. Future research efforts are needed to replicate these findings and to assess any potential long-term or multiplicative effects of engagement-based tasks, or other strategies that could enhance positive engagement with the environment.

Keywords: natural environments, restorative environments, green exercise, sustained attention, engagement, psychological well-being

INTRODUCTION

Contact with natural environments has consistently been shown to improve psychological and cognitive outcomes (Hartig et al., 2014). A vast amount of past research has focused on contrasting the effects of urban and natural environments (summarized in a systematic review by Bowler et al., 2010) or on the specific qualities of environments that promote affective or attention restoration (for example, Stigsdotter and Grahn, 2011; Gatersleben and Andrews, 2013). The cognitive processes and the quality of interaction with nature leading to a restorative experience have, however, been underexplored (Markevych et al., 2017) although they are key components in the dominant theories explaining the benefits of contact with nature, Attention restoration theory (Kaplan and Kaplan, 1989) and Stress reduction theory (Ulrich, 1983). In particular, we do not know if the benefits of a nature experience are a result of gaining distance from everyday concerns or if they are rather a result of positive engagement with natural elements (Hartig et al., 2014). Preliminary evidence suggests that focusing on the surrounding environment during nature visits is connected to greater recalled restoration, although it is not the only means of experiencing it (Pasanen et al., 2018). Thus, it may be that active engagement and interaction with the surrounding environment is not a precondition for restorative experiences but it may facilitate them.

Attention restoration theory states that the benefits of interaction with nature are largely due to cognitive benefits and "soft," effortless fascination (Kaplan and Kaplan, 1989). The theory identifies four qualities that contribute to a restorative experience. *Fascination* implies that there is something in the surroundings that captures one's attention in a non-depleting, replenishing way (Kaplan and Kaplan, 1989). *Extent* assumes that the environment should have coherent scope such that one feels like being in a whole other world (Kaplan and Kaplan, 1989). *Being away* means being mentally detached from everyday worries and concerns (Kaplan and Kaplan, 1989). Finally, the environment should match one's current needs to support restoration, thus, *compatibility* is important (Kaplan and Kaplan, 1989). In applied research in environmental psychology, these four qualities have often been interpreted as external, physical qualities, even though Attention restoration theory describes them as components of person-environment interaction (Kaplan, 2001). From this interaction perspective, the role of an individual in need of restoration is an active one, as opposed to being a passive recipient of some pre-determined restorative cues. This idea of active engagement in environmental experiences has been implied in Attention restoration theory, although applied research has not emphasized it (Kaplan, 2001).

Supporting the notion of attention restoration, the cognitive benefits of contact with nature have been demonstrated, from exposure times ranging from 40 s to 55 min (Berto, 2005; Berman et al., 2008; Lee et al., 2015; Pilotti et al., 2015). Recent evidence has suggested that some of the associated cognitive benefits can be enhanced by targeting active engagement with the environment. In a study by Lin et al. (2014), participants were shown five pictures of urban streetscape with trees for a total of 100 s, and their directed attention was measured by the digit span backward task before and after viewing the images. The participants who were instructed to pay special attention to the greenery (trees and plants) in the images improved their directed attention more than another group who were instructed to observe the environment in general (Lin et al., 2014). Thus, focusing specifically on natural features seems to enhance attention restoration.

A similar effect of active engagement on improved cognition has been shown over longer periods in intervention studies (Duvall, 2011, 2013; Lymeus et al., 2018). Lymeus et al. (2018) found improved performance in an attention task followed by 5 weeks of restoration skills training in garden settings, compared with conventional mindfulness training in a classroom with no outdoor views. In Duvall's studies (Duvall, 2011, 2013), participants were divided into two 2-week walking interventions: a standard condition with planned walking schedules, and an engagement condition where the participants were additionally given several options for engaging with the environment during the planned walks (so called awareness plans). The participants in the engagement group experienced better attentional functioning and less frustration at the end of the study, whereas there was no similar change in the reference group (Duvall, 2011). These results suggest that engagement may be useful for short-term attentional functioning and day-to-day replenishment of cognitive resources.

In the Stress reduction theory (Ulrich, 1983), interaction with the environment is described to start with physiological and initial affective responses, and continue with more elaborated affective, cognitive, and behavioral changes (Ulrich et al., 1991; Hartig et al., 2003). Stress plays a key role in this theory: affective and physiological restoration presumes that the participant is in an initially stressed, highly aroused state that a natural environment helps to restore (Ulrich, 1983). Accordingly, exposure to natural environments have been suggested to function as a buffer that reduces the negative effects of stress on well-being (Wells and Evans, 2003; Mitchell and Popham, 2008; Hartig et al., 2014). Regarding different aspects of stress markers,

the evidence is stronger for positive affective changes followed by exposure to natural versus built environments compared with physiological stress indicators (Barton and Pretty, 2010; Bowler et al., 2010; McMahan and Estes, 2015). Thus, it is likely that the physiological effects of exposure to a restorative environment not only appear but also diminish quickly (Hartig et al., 2003).

Potential stress-reducing effects of contact with nature may guide stressed individuals to seek natural environments repeatedly (Russell and Snodgrass, 1987; Gulwadi, 2006). This idea of using and choosing environments for coping is incorporated in the concept of *favorite places* (Korpela, 2003). Favorite places combine the ideas of self- and emotion-regulation, place attachment, place identity, and restoration theories (Korpela, 2012). Most identified favorite places are in natural settings or nearby water, and visits to them provide the more self-reported restoration compared with other types of favorite places (Korpela et al., 2010). However, it is currently not known how common it is to use an environment as a means of stress and emotional regulation (Hartig et al., 2014). Some evidence suggests that adults prefer to go to "classic" natural environment when feeling either happy or sad more than to other types of environments such as urban areas, "unsafe" nature, living rooms, and shopping malls (Johnsen and Rydstedt, 2013).

Even though the restorative experiences described in Stress reduction theory and Attention restoration theory are conceptually different, they have been seen as complementary processes that interact with each other (Kaplan, 1995; Markevych et al., 2017). Stress reduction theory assumes that restoration is a response to visual properties in the environment and their preference evaluation, which quickly results in physiological and affective relaxation (Ulrich, 1983). In Attention restoration theory, the first phase of restoration involves 'clearing the head,' that is, removing excessive cognitive residue, followed by recovery of directed attention, facing challenges in one's mind, and finally, more general life reflection (Kaplan and Kaplan, 1989; Korpela and Hartig, 1996). Integrating these perspectives, Hartig et al. (1991) proposed that a restorative experience begins with physiological and attentional recovery, which are followed by affective changes.

TABLE 1 | Descriptive information of the study settings and the participants.

	Study 1	Study 2
Length (km)	6	4
Environment	Coniferous/mixed forest in the countryside	Urban park near the city center
Where were the tasks read from?	Signposts along the trail	Mobile application
Alternative tasks	Same tasks in the reverse order	Awareness-enhancement tasks (Duvall, 2011)
Design	2 × 2 × 2 (pre-post, tasks/no tasks, route direction)	2 × 3 (pre-post, tasks/no tasks/alternative tasks)
Participants (valid)	150 (127)	122 (119)
Mean age [range]	50 [18–81]	40 [18–63]
Women (%)	80	87

Drawing together Attention restoration theory, Stress reduction theory, and favorite place studies, restoration can be seen as a multi-phasic experience in which individuals can have an active role by interacting with an environment that supports their (restoration) needs. Restorative experiences, in turn, can be important for more general well-being (Hartig et al., 2014). In this paper, we explore whether affective and attention restoration could be enhanced by psychological instructions that aim to deepen the different phases of a restorative experience by conducting two experimental field studies.

THE PRESENT STUDIES

To study the restorative effects of instructed interaction with the environments, we conducted two field experiments where participants walked along a nature trail, either with or without psychological tasks (descriptives in **Table 1**). Both studies had two versions of the tasks, one that was hypothesized to be more restorative than the other. The tasks that we hypothesized to be the most restorative were based on restoration theories (Attention restoration theory, Stress reduction theory, and favorite place studies) and their contents followed the different phases of restoration described in the introduction: physiological and affective relaxation, mood-enhancement, building an affective relationship with a place, and general life reflection (Korpela et al., 2017). We labeled these 'restoration-enhancement tasks.' The comparison tasks were either the same tasks in the reverse order, that is, mismatched with the hypothesized phases of restoration (Study 1), or 'awareness-enhancement tasks' inspired by Duvall's studies (Duvall, 2011, 2013; Study 2). The participants completed self-evaluated questionnaires on restoration and mood (valence, activation) and a behavioral task on sustained attention before and after the walk.

We hypothesized that walking the nature trails would provide initial benefits: (1a) enhance restoration and valence and reduce activation, and (1b) reduce errors and shorten and stabilize response times in the sustained attention task (Ulrich, 1983; Kaplan and Kaplan, 1989; McMahan and Estes, 2015). We further hypothesized that the above benefits (1a—b) would differ between the study conditions: (2a) the benefits would be greatest after conducting the restoration-enhancement tasks that follow the theory-driven phases of restoration, (2b) the benefits would be smallest after walking without the tasks (due to less interaction with the environment), and (2c) the benefits for those who conduct the comparison tasks would lie between those two. The studies are conceptual replications of each other, with similar procedures (depicted in **Figure 1**). Study 1 assesses whether any potential restorative effects of conducting the restoration-enhancement tasks depend on the order of the tasks. Is the theory-driven order ideal in terms of experienced restoration after a nature walk? In Study 2, we focus on exploring if the restoration-enhancement tasks have a similar effect as other types of psychological tasks that guide interaction with the environment but do not address restoration in particular. How relevant is the content of the tasks for restorative outcomes? In the next sections, we present the two studies in more detail. At

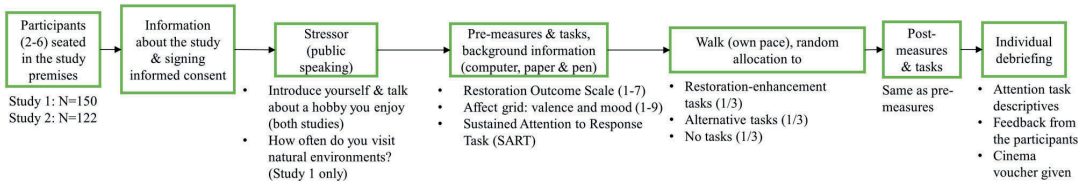

FIGURE 1 | Study procedures.

the end of this paper, we return to a more general discussion on the common themes of the studies.

Study 1 – Coniferous Forest

We began investigating the topic of instructed engagement with the environment during nature visits on a nature trail that had been developed for another project in 2010 (Korpela et al., 2017). For the present study, the trail was equipped with signposts containing the theory-based restoration-enhancement tasks aimed to strengthen affective and attention restoration. We were specifically interested in (1) whether these psychological tasks would aid restoration in general, compared with a walk without tasks, and (2) if the effects of these tasks were stronger when conducted in a theoretically and empirically determined order that mirrored the phases of a restorative experience (physiological, affective, cognitive), compared with the reverse order. Conducting the tasks in the reverse order provided a strong theoretical test, and it was relevant from practical perspective, as the circular route containing the signposts could just as easily be walked in the opposite direction in real life. As the signposts were built into the ground, we assigned four separate groups of participants to walk the route in both directions, with and without the restoration-enhancement tasks.

Materials and Methods

The study site

The 6-km-long circular trail was located in Ikaalinen, a small municipality in Pirkanmaa, Finland. The before and after measurements were taken at meeting rooms at Ikaalinen Spa, a commercial wellness center that provides both recreational and rehabilitation services. The scenery along the route varied, although it was predominantly a typical Finnish natural environment with lakes, some residential houses, a large sandpit, and forests that were both unpleasant (recently clear-cut forest) and pleasant (a scenic viewpoint by a lake). By the Corine Land Cover 25 ha (2012) classification, approximately 3.2 km of the trail was situated within a 'coniferous forest,' 1.2 km (beginning and end around the spa) of the trail were classified as 'industrial or commercial units' (with a lake on the side), 1.1 km as 'mixed forest' (with the scenic viewpoint), and 0.5 km as 'fields.'

On average (measured by median and mode), it took 103 min to walk the route, with a range of 65–155 min. The route contained several crossings where the participants were guided by yellow ribbons and printed instructions, containing both pictures and written guidance. Originally, the route with the signposts was marked with arrows that guided visitors to walk in the clockwise direction.

Participants

Altogether 150 volunteers participated in 35 sessions (**Table 1**). Contrary to our initial plan, we could not recruit visitors at the spa and consequently, the majority of participants signed up after reading about the study in a regional newspaper and via the project's Facebook page. Other recruitment means included a local newspaper, e-mail invitations to local companies, and advertisements at supermarkets in nearby areas. The study was called 'Forest walk study,' and the participants were given information about the procedure and the type of measures (e.g., an attention task) but no specific information about the experimental conditions. We conducted one pilot study with volunteer psychology students (n = 6) who received no compensation for participation, and a second pilot (n = 6), after which the procedure was significantly clarified. Of the remaining 144 participants, a further 15 were excluded due to the following criteria: not walking the instructed route (n = 7), problems with the procedure during one study session (n = 6), impaired senses (n = 1), and personal withdrawal (n = 1). For five participants, the attentional task was either not valid or missing. Ten sessions were canceled due to bad weather. The final sample consisted of 129 participants.

For the majority of the sample (92%), the route was new. Many participants showed a special interest in natural environments (we explored this indirectly in the social stressor task, described in Section "Procedure"). In the whole sample, the participants reported visiting nature 3.9 times per week on average, which is more than the national mean of 2−3 times per week (Sievänen and Neuvonen, 2011).

Procedure

The procedure is illustrated in **Figure 1**. The participants came in groups of 2−6 people, mainly from the surrounding municipalities in the region. They were seated in a meeting room in front of a desk with a laptop, a pen, and an envelope that contained the written tasks. First the researchers (most commonly two project workers) introduced themselves, the study, and the procedure, after which the participants signed the informed consent. Further information about the experiment was then detailed. The participants were asked not to talk aloud during the measurements and to refrain from using mobile phones during the study.

We conducted the experiments during the holiday season (May−September 2016) when stress levels may be lower than usual (de Bloom et al., 2010). To induce a mildly stressed state that could potentiate restorative effects (Ulrich, 1983), we started with a social stressor task, after which the participants completed the self-reported questionnaires and the behavioral measurements. When they were finished, the participants left the room in their own pace and they were given verbal and written instructions for the walk one by one outside the study room. The participants were instructed to walk by themselves. Before and after the walk, the participants could help themselves to some fruit, fresh juice, and water. After the walk, the respondents returned to the study room to complete the tasks in the same order as before the walk. At the end of the session, we showed each participant descriptive statistics of their attention task results, asked for feedback on the study, and gave everyone a cinema voucher. The procedure took approximately 2.5−3 h per person.

In addition to the measures reported in this paper, the participants completed self-reported measures of empathic feelings and vitality and a behavioral task of frustration tolerance, but these are reported elsewhere due to space constraints and different theoretical reasoning. The study was carried out in accordance with the recommendations for "Responsible conduct of research and procedures for handling allegations of misconduct in Finland 2012" by the Finnish advisory board on research integrity (TENK). The protocol was approved by the Ethics Committee of the Tampere Region. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

Study conditions

To control for any effects of weather, the participants were randomly allocated to different walking conditions each study day: 1/3 were assigned to a walk with the restoration-enhancement tasks completed in the designed, theory-based order (which we will call 'clockwise order' because they walked the route in the clockwise [C] direction), 1/3 were assigned to a walk with the restoration-enhancement tasks completed in the reverse order (hence, they walked the route in the reverse [R] direction), and the rest to a walk without tasks, of which one half (1/6 of the sample) walked the clockwise (C) and another half (1/6) the reverse (R) route. The participants in the 'no task' conditions walked the route in opposite directions to account for any potential environmental differences, and the initial idea was to combine these conditions for the analyses.

The psychological instructions

The instructions on the signposts were based on Stress reduction theory (Ulrich, 1983; Ulrich et al., 1991), Attention restoration theory (Kaplan and Kaplan, 1989), and favorite place studies (Korpela et al., 2008; Korpela and Ylén, 2009). Integrating these theories, a restorative experience has been suggested to start with physiological relaxation, followed by affective and mood-enhancing responses, and advance to building an affective relationship with the place and reflection on one's current situation in life (Korpela et al., 2017). Thus, the first three signposts related to physical relaxation and observing the environment (for example, "[. . .] Keep looking around and let yourself be enchanted by your surroundings. Keep breathing peacefully."), the next two to favorite place identification and reminiscence ("Find your favorite place in this area [. . .] Choose a detail by which you may remember this place, perhaps for years."), and the final two to clearing the mind and life reflection ("Look around for something representing you or your current situation in life [. . .] Are you gaining new thoughts?").

Pre- and post-walk measures

Self-reported restoration was measured with the 6-item Restoration Outcome Scale (ROS; Korpela et al., 2008; see also Hartig et al., 1998; Staats et al., 2003). The scale is a self-evaluation of attention restoration (one item: "I feel alert and able to concentrate"), relaxation and calmness (three items, for example, "I feel restored and relaxed"), and clearing one's thoughts (two items, for example, "My thoughts are clear"). Participants rated their current state on a 7-point rating scale ranging from "Describes my experience..." 1 = not at all to 7 = completely. We calculated the mean summary score of the responses in both pre- and post-measurements (Cronbach's $\alpha = 0.85$ and 0.89, respectively).

Mood was measured with a two-dimensional affect grid (Russell et al., 1989) in which the participants are asked to evaluate their mood by marking a single cross in a 9×9 grid. The axes reflect core affects, *valence* (horizontal axis) and *activation* (vertical axis; Russell et al., 1989; Västfjäll and Gärling, 2007).

Sustained attention was measured using the Random version of the Sustained Attention to Response Task (SART), a test of sustained attention (Robertson et al., 1997). In the SART, participants respond to the digits 1–9, presented in a random order (each shown 25 times in five different font sizes) on a screen for 4.3 min. They were instructed to press the space bar whenever they saw any digit (Go) except the digit 3 (No-Go). The participants were asked to pay equal attention to speed and response accuracy. The stimulus was shown for 250 ms, followed by a mask (a white cross within a circle) for 900 ms. We used the source code provided by Stothart (2015) in the open-source software PsychoPy (Peirce, 2009), in which we translated the instructions into Finnish. The participants were seated approximately 40 cm from the screen of a Dell Latitude laptop, although they were free to move further or closer during the experiment. Both pre- and post-tests were preceded by a practice round with 18 digits where the participants received immediate feedback on the accuracy of the response (correct/incorrect).

The SART provides a number of sustained attention measures. Commission errors – the number of responses made to the No-Go digit '3', reflect response accuracy, controlled attention (Manly et al., 2003), and response inhibition (Johnson et al., 2007). Omission errors − the number of non-responses to a Go digit − had a median of 1 and thus, there was little variation to examine and we excluded the measure from the analyses. The mean and standard deviation (SD) of response time (RT) were calculated after excluding responses to the digit '3' and RTs < 100 ms. SDRT reflects the stability of the response style, with larger variability indicating more attentional lapses

(Robertson et al., 1997; Manly et al., 2003; Smilek et al., 2010). The sequence of 225 RTs per participant was further analyzed using a Fast Fourier Transform (FFT) based on the method described in Johnson et al. (2007). Two dependent measures were derived from these FFT analyses – the slow (SFAUS) and fast (FFAUS) frequency areas under the spectra. For the SFAUS, the RT data were analyzed over the entire task. For the FFAUS, the RT data were analyzed in a first half versus second-half analysis. The SFAUS is a measure of all sources of variability in RT slower than 0.0772 Hz, which is derived from the Fixed version of the SART and represents one cycle of a presentation of the digits 1–9 (Johnson et al., 2007), and it measures gradual change in speed of responding over the course of the task. The FFAUS is a measure of all sources of variability faster than 0.0772 Hz, representing trial-to-trial variability in responding, and it measures moment-to-moment variability in responding.

Covariates

Stress in the past 4 weeks, which potentiates restoration effects (Ulrich, 1983), was measured by 10-item Perceived Stress Scale (Cohen et al., 1983), of which we calculated the summary score (Cronbach's $\alpha = 0.84$). *Age* was asked in full years. Older samples have been found to experience greater affective changes after nature exposure (McMahan and Estes, 2015) but we also hypothesized that older participants may find the lengthy route more exhausting, which could be reflected in lower restorative changes. For the majority of participants, the *start time* was at 10.30 am but it varied from 10 am to 4 pm to accommodate as many participants as possible. Time of day can, however, influence the level of alertness and task performance (Monk and Leng, 1982). We coded the start times as −1 = morning (10 − 10.30 am), 0 = midday (12 am − 1 pm), and 1 = afternoon (3 − 4 pm). As a *post hoc* measure, we recorded if the participants reported *problems with wayfinding* during the walk. Having to focus on navigation in a new environment requires mental effort which can reduce any potential restorative effect (both attentional and affective; Gatersleben and Andrews, 2013). We also recorded walk duration, weather, temperature, gender, and the number of hours slept the night before but these were not related to the outcomes in either of the two studies (**Appendices A, B, D, E**).

Data analysis

The *a priori* sample size was calculated as a 3×2 between-group repeated measures MANOVA with several correlating dependent variables, with a power of = 0.95 and alpha = 0.05. In this type of design, a medium effect size of 0.25 would be detected with a sample size of 165 participants (Gpower 3.1 software; Faul et al., 2007). However, as the final number of valid cases was lower than we aimed for, the following analyses have less statistical power than we expected to have.

Prior to the actual analysis, we checked that there were no differences between the groups at baseline in any of the outcomes with a one-way analysis of variance (ANOVA) in SPSS version 24 (provided in **Appendix C**). We also checked for differences in the outcomes between the two 'no task' groups that walked the route in different directions. Our initial plan had been to combine these two groups but as there were differences between them, we kept them separate in the analyses. However, we interpreted the results related to them with caution due to their smaller sample size.

We compared the change between pre- and post-measurements with multigroup regression analysis using Mplus version 7.4. The data was continuous but non-normally distributed so the MLR estimator was used (Muthén and Muthén, 1998/2012). The grouping was based on the direction of the route (clockwise/reverse), and completing the restoration-enhancement tasks was an explanatory variable (for simplicity, however, we present these estimates in the results as the difference between within-group intercepts, that is, the estimated within-group means). To retain more power in the analyses, we pre-selected those covariates that correlated significantly ($p < 0.05$) or showed a significant mean difference (in ANOVA) in at least one of the outcomes in either Study 1 or Study 2 (if applicable; these analyses are provided in **Appendices A, B, D, E**). Continuous covariates were centered and ordinal/dichotomous covariates were recoded so that their midpoint was at 0. In the initial models, the covariates were assumed to have a similar effect in both groups. If the standardized residuals for the covariates were large ($>|1.96|$), we relaxed this assumption and retained the modified model if the overall model fit improved.

In addition to the residuals, we checked how the models fit with the data and compared the models with the following criteria: a non-significant χ^2-test, Satorra–Bentler corrected χ^2 difference-test (for model comparison), smaller values for information criteria (Akaike's Information Criteria [AIC], Bayesian information criteria [BIC], and sample-adjusted BIC), Comparative Fit Index (CFI) and Tucker-Lewis Fit Index (TLI) ≥ 0.95, the Root Mean Square Error of Approximation (RMSEA) ≤ 0.05, and the Standardized Root Mean Square Residual (SRMR) ≤ 0.08 (Tucker and Lewis, 1973; Bentler, 1990; Browne and Cudeck, 1992; Hu and Bentler, 1999; Satorra and Bentler, 2010; Kline, 2016). To check for influential outliers we examined Cook's distances in the first models for each block of outcomes, and if they exceeded 1.00 (Tabachnick and Fidell, 2014), the analyses were re-run without the most influential cases by excluding them one by one. If excluding an influential outlier improved the model fit, we retained the improved model.

To account for correlations between related outcomes but to retain more power in the analyses, we analyzed the outcomes in blocks of three: (1) self-reported measures (restoration, valence, and activation); (2) traditional SART measures (commission errors, RT, and SDRT); (3) refined SART variability measures (FFAUS in the 1st and 2nd halves of the tests, and SFAUS).

Sensitivity analyses

If applicable, we ran two types of sensitivity analyses for the final models: (1) for those models where we deleted influential outlier(s), we re-ran the final models with those outliers, (2) for the model with refined SART variability measures, we re-ran the models excluding participants whose mean RT was > 500 ms. RTs > 500 ms are generally considered slow in SART studies with adult participants and slower RTs can be connected to inflated FFAUS and SFAUS, which, in turn, may bias the model estimates.

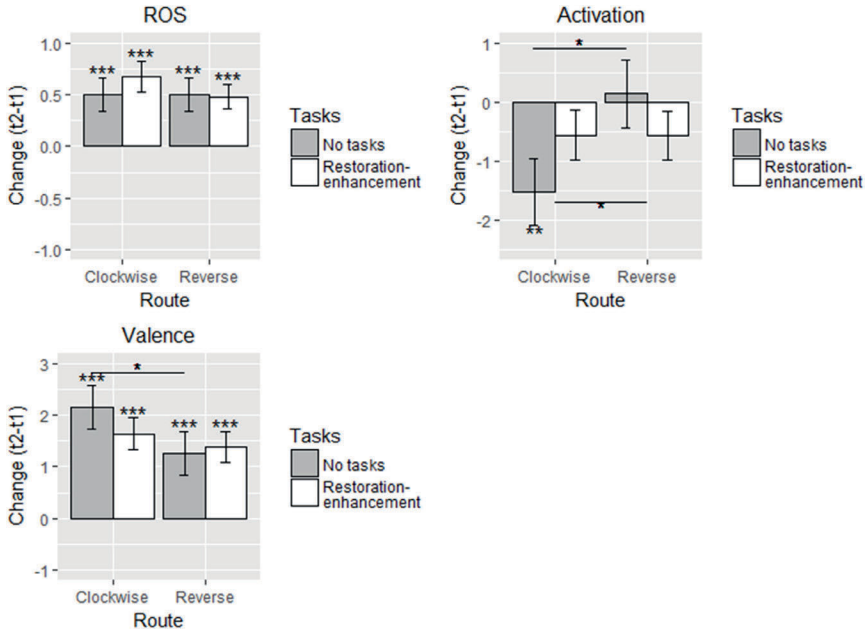

FIGURE 2 | Adjusted means in different conditions for the self-reported measures in Study 1 (n = 129). Solid line: statistically significant between-group difference. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

We ran these second sensitivity analyses to assess whether the results for FFAUS and SFAUS were influenced by respondents with slow mean RTs.

Results

Self-reported restoration and mood

Participants in all conditions reported greater restoration after the walk but there were no differences between the conditions (supporting hypothesis 1a but not 2a−c; **Figure 2** and **Table 2**). The estimated change varied, on average, between 0.48 and 0.67 units on the original 1−7 scale. Similarly, in terms of estimated valence, hypothesis 1a but not 2a−c gained support, as the participants reported feeling, on average, 1.27−2.16 units more pleasant after the walk in all conditions. Activation, in turn, did not change in most groups which was against our hypotheses 1a and 2a−c. The exception were the participants in the 'no task' (C) condition who felt 1.52 units calmer after the walk.

The change in restoration was greater for younger and more stressed participants (**Table 2**). Having a problem with wayfinding was connected to a more negative change in both self-reported restoration and a less positive mood (**Table 2**). Start time was not connected to changes in the self-reported measures.

The model explained self-reported restoration best (R^2's 0.20−0.21), followed by valence (0.11) and activation (0.04). The model fit well with the data and no influential outliers were excluded or large residuals freed (**Table 2**).

Sustained attention – traditional measures

The participants who either walked without tasks or conducted the restoration-enhancement tasks in the reverse order made 1.49 − 2.57 less commission errors after the walk (**Figure 3** and **Table 3**), supporting hypothesis 1b in these groups. The trend was the same for the participants who conducted the restoration-enhancement tasks in the clockwise order, although the estimate (−1.22) was not statistically different from zero (**Table 3**). Similarly, SDRT reduced significantly in the condition with the reversed restoration-enhancement tasks, and the trend was to the same direction in both 'no task' conditions (showing partial support for hypothesis 1b but not 2a−c). With mean RT, there were no significant changes before and after the walk in any of the conditions (contrary to hypothesis 1b) but there was an unexpected interaction effect between route and tasks. Conducting the tasks was associated with increased mean RT compared with not conducting them in the clockwise route, whereas in the reverse route, conducting the tasks was associated with decreased mean RT compared with not conducting them (**Figure 3**). All these results were in contrast with our hypotheses 2a−c because they indicated the least benefits from conducting the restoration-enhancement tasks in the clockwise order.

Age, stress in the past week, or start time were not significantly connected to changes in the outcomes but reporting problems with wayfinding was (**Table 3**). Those who reported problems with wayfinding made almost three more commission errors and had a significantly faster mean RT after the walk (**Table 3**).

TABLE 2 | The results for multigroup regression models for the self-reported measures in Study 1 ($n = 129$).

		Self-reported restoration				Valence				Activation			
		b	*SE*	*p*	β (C/R)	*b*	*SE*	*p*	β (C/R)	*b*	*SE*	*p*	β (C/R)
Mean difference, estimated	(1) Restoration-enhancement tasks (C)	0.67***	0.15	0.00	0.84	1.64***	0.30	0.00	0.99	−0.56	0.42	0.19	-0.23
	(2) Restoration-enhancement tasks (R)	0.48***	0.12	0.00	0.66	1.39***	0.30	0.00	0.84	−0.56	0.41	0.17	-0.28
	(3) No tasks (C)	0.50***	0.16	0.00	0.63	2.16***	0.42	0.00	1.30	−1.52**	0.57	0.01	-0.62
	(4) No tasks (R)	0.50***	0.17	0.00	0.69	1.27***	0.42	0.00	0.76	0.14	0.57	0.77	0.07
	Task × route interaction (difference '1–3' − '2–4')	−0.19	0.26	0.47		0.64	0.57	0.26		−1.66*	0.83	0.05	
Covariates	Stress	0.24*	0.11	0.03	0.17/0.19	0.38	0.30	0.21	0.13	−0.29	0.36	0.42	-0.07/-0.08
	Start time	0.03	0.11	0.75	0.03/0.04	0.23	0.23	0.33	0.09/0.11	−0.24	0.32	0.45	-0.07/-0.10
	Age	−0.01	0.00	0.05	-0.15/-0.18	−0.01	0.01	0.57	-0.05	0.00	0.01	1.00	0.00
	Wayfinding problems	−0.70**	0.23	0.00	-0.28/-0.31	−1.25*	0.56	0.02	-0.24	−0.08	0.56	0.88	-0.01
R^2 (C/R)				0.20/0.21				0.11/0.11				0.04/0.04	

$\chi^2 = 7.89$ ($df = 15$, $p = 0.93$), RMSEA < 0.001, CFI = 1.00, TLI = 1.28, SMRM = 0.04. Grouping is based on walking direction: C, clockwise; R, reverse route; figures separated by "/" if they differ between the groups.
** $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

The variances explained were nearly 0.09 for changes in commission errors, 0.12−0.13 for changes in mean RT, and 0.05−0.07 for changes in SDRT. The model with two freed parameters fit the data well (**Table 3**).

Sustained attention – refined variability measures

In the refined SART variability measures, there were several influential outliers and even after deleting the four most influential ones, the standard errors of the intercepts were large (**Figure 4** and **Table 4**). The participants had similar amounts of FFAUS in the first half of the tasks (against hypotheses 1b and 2a−c), whereas in the second half only the group who conducted the restoration-enhancement tasks in the reverse order showed reduced FFAUS (partially supporting hypothesis 1b; **Figure 4** and **Table 4**). Similarly, this group performed the SART with less SFAUS throughout the whole test after the walk, whereas the other groups showed no change. Our hypothesis 1b was, therefore, supported in only one group, and this group was not the one we hypothesized (2a) to show the greatest improvements.

Those who participated later in the day (and walked the clockwise route) performed the SART with more FFAUS in the 2nd half of the test, whereas problems with wayfinding were connected to reduced SFAUS after the walk (**Table 4**). Stress and age were not connected to the refined SART variability measures (**Table 4**).

The variances explained were low for the FFAUS in the 1st (0.03−0.06%) and the 2nd half (0.02−0.07), merely exceeding the minimum recommended R^2 for practically significant effect of 0.04 (Ferguson, 2009). For the SFAUS, the model explained 0.08−0.12 of the change between the measurements. Altogether four outliers were deleted and two parameters freed to obtain a good fit with the data (**Table 4**).

Sensitivity analyses

In the first sensitivity model for the refined SART variability measures including the 4 outliers deleted from the final model, the model fit was extremely bad in terms of all assessed criteria (for example, CFI = 0.438) and thus we found it meaningless to assess its results. In the second sensitivity model excluding those whose mean RT was > 500 ms, the intercept estimates of SFAUS and FFAUS in the 2nd half were no longer statistically significantly different from 0 for the group who conducted the restoration-enhancement tasks in the reverse order (however, the trend was the same). Therefore, the result that conducting the tasks in the reverse order, but not in clockwise order, improved sustained attention in terms of reduced variability was only partly supported in this analysis.

Discussion

Our first main result was that self-reported restoration and valence improved in all conditions but this was not connected to conducting the psychological tasks. Activation remained mostly similar. The second main result was that overall, sustained attention performance, as measured by the number of commission errors, improved after the walk, whereas the speed and stability of responding did not change substantially. Unexpectedly, the participants who completed the restoration-enhancement tasks in the reverse order improved their sustained

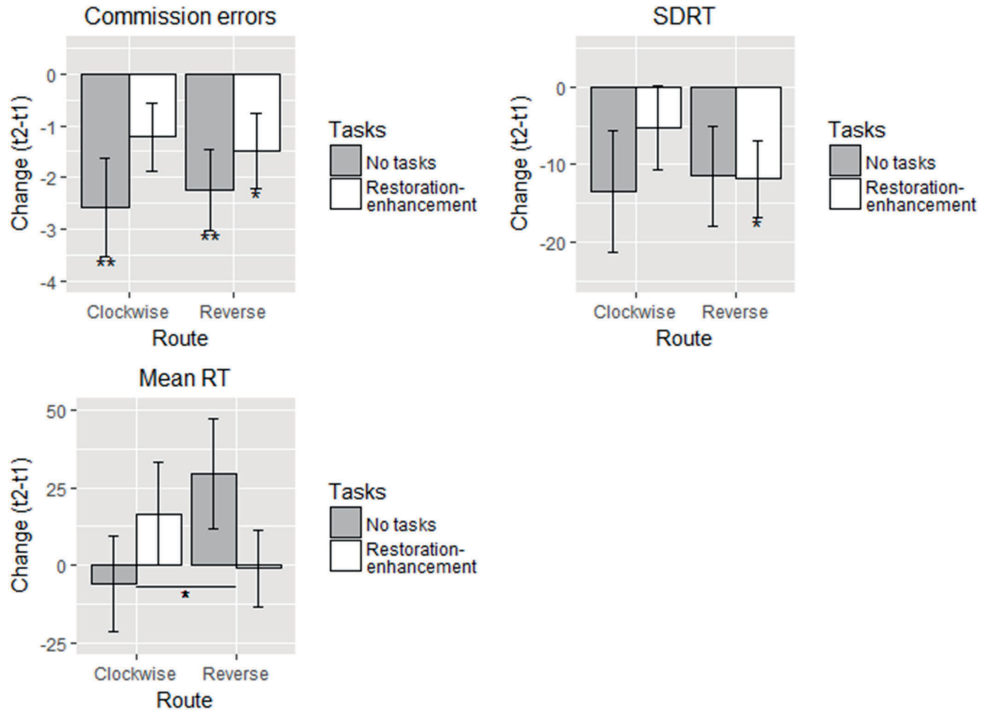

FIGURE 3 | Adjusted means in different conditions for the traditional SART measures in Study 1 (n = 125). Solid line: statistically significant between-group difference. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

attention performance (evaluated by reduced commission errors and RT variability) most consistently, whereas those who conducted the tasks in the clockwise order showed no changes in sustained attention. In both 'no task' conditions, sustained attention improved only in terms of commission errors. Thus, comparing the two conditions where the restoration-enhancement tasks were conducted in different orders, it appeared that the reverse order was more ideal for attention restoration than the hypothesized, theory-driven order. Based on this consistent finding, we modified the contents of the restoration-enhancement tasks for Study 2.

One limitation of this study was that wayfinding was difficult for some. Those who reported problems with wayfinding (n = 15) systematically reported lower levels of restoration and valence after the walk. They also responded more impulsively in their sustained attention task, meaning that they performed the SART with consistently faster RTs, combined with an increased number of commission errors and reduced variability (probably due to the fast speed of responding). The fact that the trail included several crossings (which, nevertheless, were marked with yellow ribbons) and required looking at a map to spot the signposts irritated some participants. Furthermore, taking an incorrect turn and having to return was a nuisance for some, although some found minor wandering around in a new environment inevitable. Most, nevertheless, thought that the trail was well marked and easy to follow.

Another limitation was that the route was different depending on the direction of the walk, which could have affected the results for several reasons. Firstly, when walking the clockwise route, the unpleasant parts of the trail (recent clearings) were toward the end of the walk, whereas in the reverse direction the end was intact coniferous forest. Recently clear-cut forests are generally regarded as unpleasant compared to intact forests or forests that have been cut less invasively (Silvennoinen et al., 2002). In addition to being visually unpleasant, some participants verbally reported feeling upset about the ecological consequences of these clearances. These kinds of reactions to the environment may have shown in their post-walk measurements. Secondly, as the signposts were numbered, the participants who completed the instructions in the reverse order could infer that they were doing them in an "incorrect" order so they were not completely blind to the study conditions. Thirdly, the trail was originally designed to be walked in the clockwise direction and thus, it was marked with arrows and was more intuitive to follow that way. Even though we marked the whole trail with yellow ribbons for this study, we chose not to use arrows pointing in the reverse route to avoid confusion, and it is probable that there was more wayfinding involved when walking the reverse route.

TABLE 3 | The results for multigroup regression models for the traditional SART measures in Study 1 (n = 125).

		Commission errors				Mean RT (ms)				SDRT (ms)			
		b	***SE***	***p***	**β (C/R)**	***b***	***SE***	***p***	**β (C/R)**	***b***	***SE***	***p***	**β (C/R)**
Mean difference, estimated	(1) Restoration-enhancement tasks (C)	−1.22	0.66	0.07	−0.30	16.64	16.29	0.31	0.20	−5.28	5.46	0.33	−0.17
	(2) Restoration-enhancement tasks (R)	−1.49*	0.73	0.04	−0.37	−0.86	12.35	0.94	−0.01	−11.86*	5.00	0.02	−0.44
	(3) No tasks (C)	−2.57**	0.94	0.01	−0.63	−5.83	15.31	0.70	−0.07	−13.44	7.77	0.08	−0.43
	(4) No tasks (R)	−2.24**	0.77	0.00	−0.56	29.21	15.31	0.10	0.41	−11.44	7.77	0.08	−0.42
	Task × route interaction (difference '1–3'-'2–4')	−0.61	1.47	0.68		−52.55*	25.10	0.04		−8.59	10.88	0.43	
Covariates	Stress	−0.92	0.64	0.16	−0.13	30.06/−5.20	19.56/12.44	0.12/0.68	0.20/−0.04	−5.20	4.79	0.28	−0.09/−0.11
	Start time	−0.40	0.47	0.39	−0.07/−0.08	9.17	10.28	0.37	0.07/0.10	−2.91	3.87	0.45	−0.06/−0.09
	Age	−0.02	0.02	0.44	−0.06/−0.07	0.23	0.44	0.61	0.04/0.05	−0.19	0.19	0.32	−0.08/−0.11
	Wayfinding problems	2.91**	0.98	0.00	0.23/0.24	−57.44*	22.73	0.01	−0.22/−0.26	−15.15	8.60	0.08	−0.16/−0.18
R^2 (C/R)		0.09/0.09				0.12/0.13				0.05/0.07			

*χ^2 = 2.87 (df = 13, p = 1.00), RMSEA < 0.001, CFI = 1.00, TLI = 1.25, SMRM = 0.02. Grouping is based on walking direction: C, clockwise; R, reverse; figures separated by "/" if they differ between the groups. Parameters freed across groups: RT regressed on stress, covariance between commission errors and SDRT. *p < 0.05, **p < 0.01, ***p < 0.001.*

For all the above reasons, the finding that the tasks improved, to some degree, sustained attention performance when they were completed in the reverse order is particularly interesting. We speculate that this may partly have to do with the contents of the final tasks and their congruence with the environment. In the clockwise route, the final task related to general life reflection which may induce all kinds of emotional responses, not solely positive ones (for example, rumination). This type of negative emotional response, especially when combined with the unpleasant scene, may have been the reason for reduced sustained attention restoration; a similar pattern was not found when walking the same route without the tasks. In the reverse route, although more difficult to follow, the end of the trail was more visually pleasant and the final task focused on physical and psychological relaxation. These factors could have induced a more fascinated and calm state and thus, according to attention restoration theory (Kaplan and Kaplan, 1989), lead to better sustained attention when walking this route.

Based on this field experiment, there was no evidence that favored completing the restoration-enhancement tasks in the designed, theory-driven order, although there seemed to be no negative effects of doing these tasks either. It is important to also note that we inspected only short-term effects. For example, reflection may not be restorative in the short-term but it can have a longer-term impact on well-being. To assess any potential longer-term effects on general well-being is, however, outside the scope of this study. Relatedly, we studied single nature visits that may not reveal the full potential of these kind of tasks. For some, it may take more time to "learn" to do the tasks, or more repetition to experience any added benefits on affective or attention restoration (Lymeus et al., 2018).

We would like to note that our participants were more nature-oriented than the general population (evaluated by the number of weekly nature visits). Participation alone required 2.5–3 h, and for most it took much longer because they traveled to the study site from other municipalities in the region. The motive to participate seemed, for many, related to an interest in visiting a new natural environment and/or research on the topic of natural environments. The fact that we found few differences between the participants who completed or did not complete the psychological tasks could also be related to the sample being nature-oriented. Some of the participants in the 'no task' conditions said that they had been disappointed because they were instructed not to do the tasks, but that they compensated by focusing on other, pleasant features during the walk (such as spotting new plant species and picking berries and mushroom while walking). It is plausible to assume that some nature-oriented people already know how they like to explore a new (natural) environment and that they are more prone to find elements there that they find interesting and engaging.

Study 2 – Urban Park

In Study 1 we found that self-reported restoration and valence improved after a forest walk in all groups, regardless of the tasks, whereas for sustained attention, conducting the restoration-enhancement tasks in the reversed order seemed the most beneficial. The aims for Study 2 were to conceptually replicate

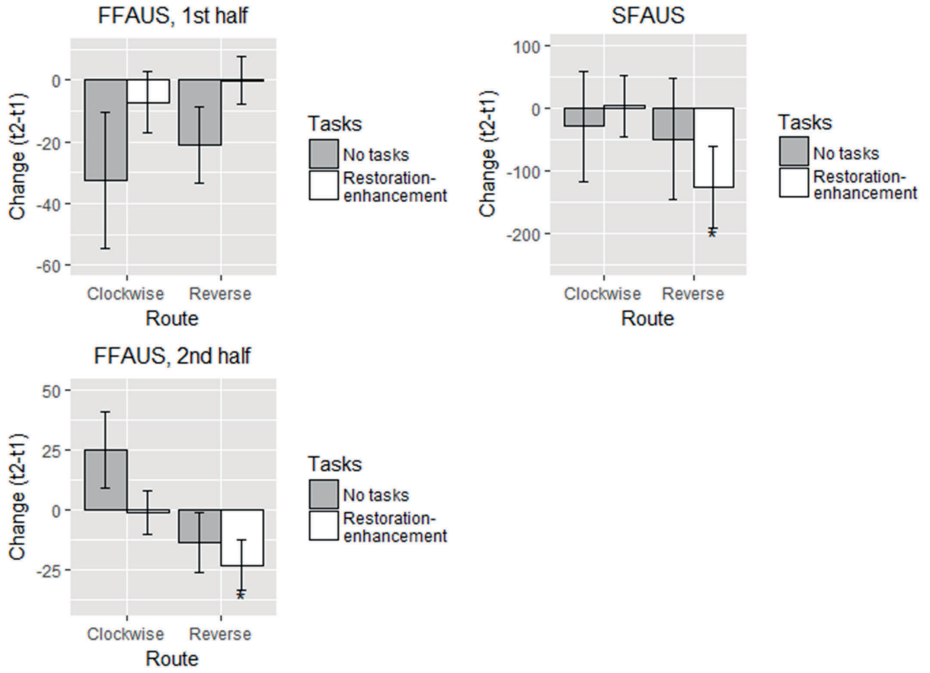

FIGURE 4 | Adjusted means in different conditions for the refined SART variability measures in Study 1 (n = 118). Solid line: statistically significant between-group difference. *$p < 0.05$, ** $p < 0.01$, ***$p < 0.001$.

Study 1, addressing its major limitations, and to investigate the effects of urban nature. The hypotheses were the same as in Study 1 (see The Present Studies).

Materials and Methods

Unless otherwise stated, the method was same as in Study 1.

Study site

The selected 4-km-long trail was within a popular, well-maintained urban park. The area is commonly referred to as Hatanpää arboretum, as it is a habitat for a vast amount of different tree, bush, and plant species, both native and exotic (City of Tampere, 2017). The park comprises three approximately equal-sized, joined parks, and the selected route went through each of these. The first part of the route went along a lake, and the return route went through the middle of the park. There were few crossings along the route and thus, wayfinding was easier than in Study 1. The surface of the route was mainly flat gravel-paved walkway. All parts of the park are located next to a hospital and a built-up residential/industrial/commercial area and thus, the Corine land cover 25ha (2012) data classifies this area as 121 'Industrial or commercial units.' The measurements were taken at a small office room in a nearby mental health service center, approximately 300 m away from the beginning of the trail. A major improvement to Study 1 was that the environment was the same for everyone as all participants walked the same route in the same direction. This way we could exclude the possibility that differences in wayfinding, aesthetics, or vegetation could influence the results.

Participants

A total of 122 working-age people participated in the study in 31 sessions. Initially many more signed up but due to bad weather we had to cancel 13 sessions throughout the summer. Participants were recruited via the project's Facebook page, by sending invitations to local e-mail lists, by placing posters in notice boards around the city center, and by an online event calendar maintained by the leading regional newspaper. To avoid having a more-than-average nature-oriented sample, we named the study "Walking study" (cf. Study 1 was named "Forest walk study"). Contrary to Study 1, we placed a restriction on age so that all participants would be aged between 18 and 64 years, for clearer generalization and prevention of potential problems with the smart phones. In the adverts, in addition to giving relevant information about the study, we stated that we were looking for volunteer participants who were aged 18–64 years; able to walk 4 km at a slow pace; able to use computers and smart phones; did not use medication that affected their concentration, heart, or psyche; and did not participate in Study 1. In the final sample, one participant was excluded because they conducted only half of the assigned tasks along the trail. The self-reports were missing from two participants and the attention task from one.

TABLE 4 | The results for multigroup regression models for the refined SART variability measures in Study 1 (n = 118).

		FFAUS, 1st half				FFAUS, 2nd half				SFAUS			
		b	*SE*	*p*	β (C/R)	*b*	*SE*	*p*	β (C/R)	*B*	*SE*	*p*	β (C/R)
Mean difference, estimated	(1) Restoration-enhancement tasks (C)	−7.21	9.98	0.47	−0.09	−1.19	8.96	0.89	−0.02	3.51	48.72	0.94	0.01
	(2) Restoration-enhancement tasks (R)	−0.15	7.52	0.98	0.00	−23.23*	10.57	0.03	−0.42	−125.97*	64.06	0.05	−0.34
	(3) No tasks (C)	−32.48	22.20	0.14	−0.42	24.92	15.86	0.12	0.41	−29.36	87.85	0.74	−0.11
	(4) No tasks (R)	−21.05	12.27	0.09	−0.43	−13.97	15.86	0.26	−0.25	−49.81	87.85	0.61	−0.14
	Task × route interaction (difference '1–3' – '2–4')	−4.36	26.98	0.87		16.86	24.55	0.49		−109.03	128.90	0.40	
Covariates	Stress	−7.45	9.20	0.42	−0.06/−0.09	5.02	8.67	0.56	0.05	45.65	36.32	0.21	0.09/0.07
	Start time	−14.53/9.98	10.19 /6.34	0.15 /0.12	−0.13/0.17	18.74*/−3.92	8.13/6.93	0.02 /0.57	0.20/−0.06	−16.36	45.82	0.72	−0.04
	Age	−0.06	0.31	0.84	−0.01/−0.02	0.09	0.37	0.81	0.02/0.03	−1.17	1.75	0.50	−0.06 / −0.05
	Wayfinding problems	−4.15	19.90	0.84	−0.02/−0.03	−19.55	22.48	0.39	−0.10/−0.12	−272.82*	118.34	0.02	−0.29/−0.24
R^2 (C/R)		0.03/0.06				0.07/0.02				0.12/0.08			

*χ^2 = 9.70 (df = 13, p = 0.72), RMSEA < 0.001, CFI = 1.00, TLI = 1.27, SMRM = 0.04. Grouping is based on walking direction: C, clockwise; R, reverse; figures separated by "/" if they differed between the groups. 4 outliers deleted; parameters freed across groups: FFAUS (both halves) regressed on start time. *p < 0.05, **p < 0.01, ***p < 0.001.*

Within the participants, visits in the area in the past 6 months varied between 0 and 320, with a mean of 8 visits (median 1). Nature-relatedness, measuring subjective connection with nature, was on average on a moderate level (3.68 on a 1−5 scale, with higher values indicating greater nature-relatedness; Nisbet and Zelenski, 2013).

Procedure

In contrast with Study 1, the stressor task was more neutral to avoid a priming effect for nature enjoyment/orientation. The participants were asked to introduce themselves and talk about a hobby they enjoyed. Two project workers guided all experiments.

We gave the participants smartphones (Lenovo A Plus) where they used the mobile application ActionTrack (license provided by the City of Tampere) which gave an audio signal whenever they were close to a "signpost." The application controlled the order of the tasks so that they could not be completed in a different order than planned, and it allowed us to manipulate the contents of the tasks and to maintain blinding to the study conditions. Using this application required no physical manipulation of the environment, as participants could see the route, the direction of the next task, and their location the whole time they were outdoors. As a back-up, all participants received a paper map with detailed instructions. We instructed them to mainly navigate with the mobile application but if there were problems with it or if they found it disturbing, they could use the paper map and instructions.

The experiment took approximately 2 h per participant, of which the walk duration was 1 h (range between 44 and 97 min). An addition to Study 1 was also that the participants' pulse was measured the whole time with GPS sports watch (Polar V800) and a heart rate sensor at the chest (Polar H7 belt), and they gave saliva samples before and after the walk. Thus, they were instructed to refrain from heavy exercise and alcohol use 24 h prior to the study, and from using caffeine, food, and nicotine 2 h before the study. In the midpoint of the route, all participants were asked three questions via the mobile phone. These additional measures will be reported elsewhere due to space constraints.

The study was carried out in accordance with the recommendations for "Responsible conduct of research and procedures for handling allegations of misconduct in Finland 2012" by the Finnish advisory board on research integrity (TENK). The protocol was approved by the Regional Ethics Committee of the Tampere University Hospital catchment area. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

The psychological instructions

We took into account that in Study 1, the theory-driven restoration-enhancement tasks did not seem to bring added value to any of the affective or attention outcomes when they were conducted in the order they were designed. Instead, these tasks in the reverse order were related to better sustained attention. We noted that in the reverse order, the relaxation tasks became the last and may have affected the respondents positively at the end of the experimental walk. Moreover, in the hypothesized order,

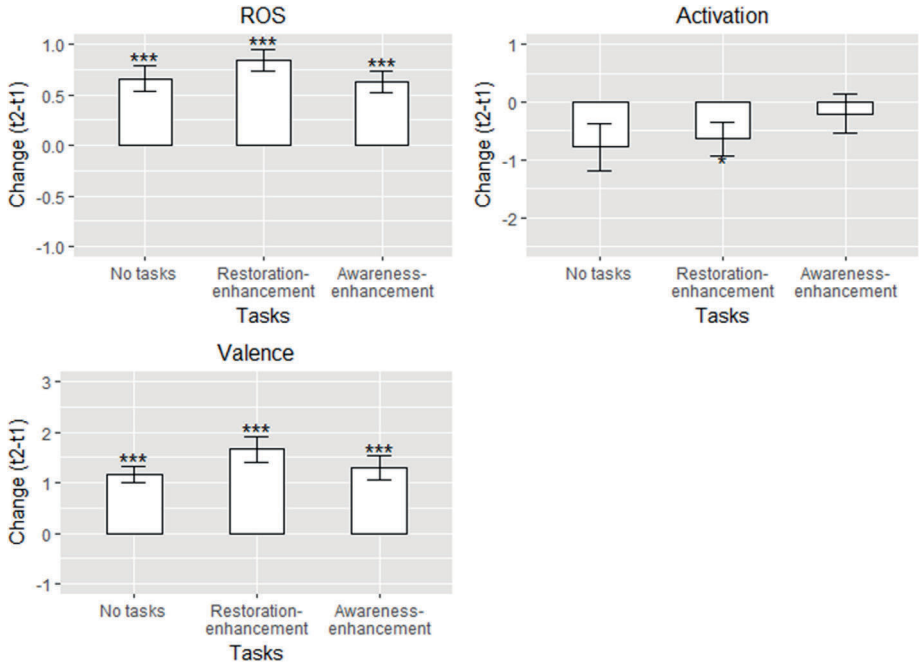

FIGURE 5 | Adjusted means in different conditions for the self-reported measures in Study 2 (n = 118). Solid line: statistically significant between-group difference. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

the task of reflecting on one's life was the last and could prime the respondents positively but also negatively, producing rumination and decrease in restoration. Thus, we updated these restoration-enhancement tasks so that they still evolved according to the restoration theories and made sense narratively but so that both beginning and end focused on affective and physiological relaxation. Tasks 1−5 remained exactly as in Study 1, but we modified Tasks 6 and 7. For Task 6, we combined the parts of Tasks 2 and 3 that related to being away and mood enhancement, and the final Task (7) was a short version of Task 1. Overall, then, the first three tasks focused on relaxation and mood enhancement, followed by identifying a favorite place (Task 4), mood relief and mindset recognition (Task 5), forgetting worries and mood enhancement (Task 6), and relaxation in the end (Task 7).

For the control task condition, we chose tasks similar to those used in Duvall's intervention study (Duvall, 2011, 2013). These alternative tasks focused on different senses (4 tasks) and taking on a new role through which one observes the environment (a magician, a photographer, and a small child; 3 tasks). We matched these tasks to the environment so that, for example, a task instructing one to focus on the sense of smell was located close to the well-maintained rose garden. Like the restoration-enhancement tasks, these 'awareness-enhancement' tasks were based on the idea of strengthening engagement and interaction with the environment (Duvall, 2011). The critical difference was that the restoration-enhancement tasks directly aimed to induce a more restored state, both physiologically (for example, "let your shoulders relax") and psychologically ("feel your mood improve"), whereas the awareness-enhancement tasks focused on engagement and sensory experiences without specifically addressing restoration.

Study conditions

As shown in **Figure 1**, the participants were randomly assigned to three different conditions: a walk without tasks (1/3 of the participants), a walk with the updated theory-driven restoration-enhancement tasks (1/3), and a walk with the awareness-enhancement tasks (1/3).

Pre- and post-walk measures and covariates

The self-reported and attention measures were the same as in Study 1. For the ROS, the reliabilities, measured by Cronbach's α's, were 0.87 before and 0.89 after the walk. The unadjusted means for each outcome before and after the walk are provided in **Appendix F**.

Covariates were the same as in Study 1 with one addition and some modifications. Based on the changes in the procedure and experiences from Study 1, instead of relying on verbal reports, we asked about the ease of *wayfinding* in the electronic questionnaire after the walk (on a 1−4 scale) and about *navigation method* (1 = 'mainly with the provided smart phone,' 2 = 'with both

TABLE 5 | The results for multigroup regression models for the self-reported measures in Study 2 (n = 118).

		Self-reported restoration				Valence				Activation			
		b	*SE*	*p*	β	*b*	*SE*	*p*	β	*b*	*SE*	*p*	β
Mean difference, estimated	(1) No tasks	0.66***	0.13	0.00	0.92	1.17***	0.16	0.00	1.13	−0.78	0.41	0.06	−0.32
	(2) Restoration-enhancement tasks (U)	0.84***	0.11	0.00	1.35	1.66***	0.25	0.00	1.06	−0.64*	0.29	0.03	−0.37
	(3) Awareness-enhancement tasks	0.63***	0.11	0.00	0.94	1.29***	0.24	0.00	0.97	−0.20	0.33	0.55	−0.10
Covariates	Stress	0.16	0.11	0.14	0.12/0.12 /0.15	0.16	0.22	0.46	0.09/0.05 /0.08	0.03	0.37	0.93	0.01/0.01/0.01
	Start time	−0.16	0.17	0.33	−0.10/−0.11/−0.09	0.02	0.26	0.93	0.01/0.01 /0.01	−0.65	0.39	0.09	−0.11/−0.16 /−0.13
	Age	0.00	0.01	0.80	0.02/0.03 /0.02	−0.02	0.01	0.10	−0.20/−0.14/−0.15	−0.01	0.01	0.56	−0.04/−0.06 /−0.05
	Navigation method (smart phone – map)	0.12/−0.27 /−0.24	0.14/0.15 /0.12	0.36/0.06 /0.05	0.13/−0.31/−0.27	−0.17	0.15	0.26	−0.12/−0.08/−0.10	−0.24	0.24	0.32	−0.07/−0.10 /−0.10
	Ease of wayfinding	0.02	0.11	0.89	0.01/0.02/0.01	0.03	0.22	0.88	0.02/0.02/0.01	0.42	0.36	0.24	0.09/0.17/0.11
R^2 (conditions 1/2/3)		0.04/0.12/0.11				0.08/0.04/0.05				0.03/0.06/0.04			

*χ^2 = 26.36 (df = 34, p = 0.82), RMSEA < 0.001, CFI = 1.00, TLI = 1.73, SMRM = 0.08. Grouping is based on the study condition; figures separated by "/" if they differed between the groups. U, updated from Study 1. Parameters freed across groups: ROS regressed on navigation method. *p < 0.05, **p < 0.01, ***p < 0.001.*

smartphone and the paper map,' 3 = 'mainly with the paper map'). *Stress* in the past 4 weeks (Cohen et al., 1983) had, again, a good reliability (α = 0.83). We also asked in the electronic questionnaire if the participants were *afraid* at any point during the walk and if they encountered anything *unusual* that may have influenced their experience (Gatersleben and Andrews, 2013), followed by an open-ended question, but they were rare or not related to the outcomes (**Appendix E in Supplementary Material**).

Data analysis

The data analyses were the same as in Study 1 (see Data Analysis) except that the multigroup models were fitted to three groups according to the study conditions.

Results

Self-reported restoration and mood

As in Study 1, participants in all conditions reported greater restoration and increased valence after the walk, and there were no between-group differences (**Figure 5** and **Table 5**). These findings support our hypothesis 1a but not 2a−c. The estimated changes in self-reported restoration were 0.63−0.84 units, and in valence 1.17−1.66 units. Activation reduced for participants in the 'no task' and the updated 'restoration-enhancement tasks' conditions (−0.78 to −0.64 units), although this change was statistically significant only in the 'restoration-enhancement task' condition (thus, the data showed partial support for hypothesis 1a; **Table 5**). In the 'awareness-enhancement tasks' condition, no changes in activation were apparent.

Stress, start time, age, and ease of wayfinding were not connected to the changes in the self-reported outcomes (**Table 5**). Using the paper map instead of smart phone was connected to a smaller change in self-reported restoration in the conditions where participants conducted tasks (**Table 5**).

Altogether, the R^2s were lower than in Study 1, although in self-reported restoration and valence they mainly exceeded 0.04, the recommended minimum cut-off for practical significance (Ferguson, 2009). In activation, R^2s varied between 0.03 and 0.06. The model fit was good with one parameter freed (**Table 5**).

SART – traditional measures

Participants in the 'no tasks' and 'restoration-enhancement tasks' conditions made 1.57 − 1.99 less commission errors after the walk compared with before (**Figure 6** and **Table 6**), whereas for those in the awareness-enhancement tasks condition, the trend was in the same direction but not significant (partially supporting hypothesis 1b). Mean RT slowed on average by 27 ms for the 'no task' group, whereas no changes were apparent in the other conditions, contrasting hypothesis 1b but supporting hypothesis 2b. For SDRT, against all our hypotheses, none of the groups showed change between the measurements.

Those who had experienced more stress in the past 4 weeks made less commission errors (in the 'no tasks' condition only) and responded faster after the walk compared to before (all conditions; **Table 6**). Start time was associated with most of the measures of sustained attention: those who participated in the afternoon made more commission errors in all groups, responded

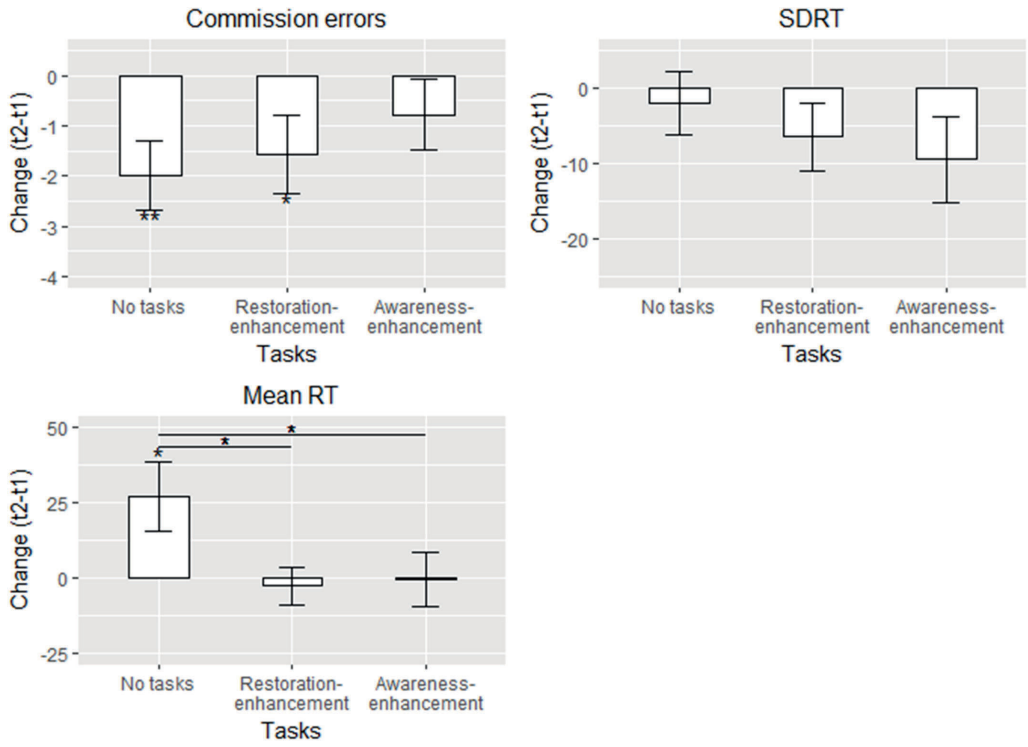

FIGURE 6 | Adjusted means in different conditions for the traditional SART measures in Study 2 (n = 116). Solid line: statistically significant between-group difference. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

faster (in two conditions), and there was less variability in their response times (in the 'no tasks' condition) after the walk (**Table 6**). Using the map instead of the smart phone for navigation was connected to an increased number of commission errors (all groups) and to a speeding of mean RT (in the 'restoration-enhancement tasks' condition). Age was not connected to the changes in the outcomes.

The variances explained were consistently highest in the 'no task' condition (0.20−0.24) and lower and more variable in the other conditions, yet exceeding the 0.04 threshold for practical significance. Initially, the model fit was very bad but improved after freeing seven parameter estimates across the groups (**Table 6**).

SART – refined variability measures

In the first half of the SART, against hypotheses 1b and 2a − c, no changes in FFAUS were apparent after the walk in any of the conditions (**Figure 7** and **Table 7**). In the second half, the participants in the 'no tasks' condition performed the task with less FFAUS; the trend was similar for participants who conducted the updated restoration-enhancement tasks but there was more variability within the group (showing partial support for hypothesis 1b but contrasting hypotheses 2a−c; **Table 7**). In terms of SFAUS, no changes occurred within or between the groups (against all hypotheses).

Age, navigation method, and ease of wayfinding were not connected to the changes in the refined SART variability measures. Participants who were more stressed performed the second half of the SART with less FFAUS after the walk (**Table 7**). Similarly, later start time predicted less FFAUS in the first half of the test.

Variances explained varied between 0.05 and 0.16 in FFAUS, exceeding the threshold for practical significance, but in SFAUS, the R^2s were poor (0.004−0.08). As in Study 1, the model for these outcomes had several large outliers, 3 of which were deleted (**Table 7**). In addition, 2 parameters were freed across groups.

Sensitivity analyses

In the sensitivity model for the traditional SART measures including the outlier deleted from the final model, the greatest difference to the final model was that more stress in the past 4 weeks was connected to lower SDRT. No substantial differences in other estimates, their significance levels or in the conclusions drawn from them were apparent.

Similarly, in the sensitivity model for the refined variability measures including the 3 outliers deleted from the final model,

TABLE 6 | The results for multigroup regression models for the traditional SART measures in Study 2 (n = 116).

		Commission errors				Mean RT (ms)				SDRT (ms)			
		b	***SE***	***p***	β	***B***	***SE***	***p***	β	***B***	***SE***	***p***	β
Mean difference, estimated	(1) No tasks	−1.99**	0.70	0.00	−0.47	27.04*	11.53	0.02	0.46	−1.91	4.22	0.65	−0.08
	(2) Restoration-enhancement tasks (U)	−1.57*	0.79	0.05	−0.32	−2.58	6.28	0.68	−0.06	−6.43	4.45	0.15	−0.27
	(3) Awareness-enhancement tasks	−0.78	0.71	0.27	−0.18	−0.26	8.95	0.98	−0.01	−9.41	5.71	0.10	−0.30
Covariates	Stress	−1.75*/ 2.51 /49	0.77 / 1.38 /0.77	0.02/ 0.07/0.53	−0.23/ 0.25/0.07	−16.03*	7.83	0.04	−0.15 / −0.17/−0.20	−8.73*	4.48	0.05	−0.20/ −0.18/−0.17
	Start time	2.74**	0.85	0.00	0.27/ 0.22/0.24	−61.86***/ −33.67*/ −14.47	12.81/ 14.33/13.25	0.00/ 0.02/0.28	−0.45 / −0.30 /−0.11	−24.01** / −1.61/0.94	7.62/ 5.97/12.31	0.00/ 0.79/0.94	−0.41 / −0.03/0.01
	Age	−0.01	0.04	0.78	−0.03/ −0.02/−0.03	−0.43/ 0.79/ −0.97	0.69/ 0.53/0.61	0.53/ 0.14 /0.12	−0.08/ 0.19/−0.20	−0.38 / 0.36/−0.28	0.36/ 0.31/0.36	0.30/ 0.25/0.44	−0.17/ 0.17/−0.09
	Navigation method (smart phone - map)	1.30**	0.48	0.01	0.23/ 0.17 /0.23	4.83/ −25.36**/ 5.96	7.83/ 8.99/8.68	0.54/ 0.01/0.49	0.06 / −0.36 /0.09	−3.16	2.95	0.28	−0.09/ −0.08/−0.08
	Ease of wayfinding	−0.67	0.72	0.35	−0.08/ −0.09/−0.08	9.93	6.95	0.15	0.08/ 0.15 /0.10	4.50	3.70	0.23	0.09 /0.13/0.07
R^2 (conditions 1/2/3)			0.23/0.09/0.13				0.20/0.16/0.06				0.24/0.07/0.04		

*χ^2 = 20.08 (df = 22, p = 0.58), RMSEA < 0.001, CFI = 1.00, TLI = 1.03, SMRM = 0.06. Grouping is based on the study condition; figures separated by "/" if they differed between the groups. U, updated from Study 1. 1 outlier deleted; parameters freed across groups: RT and SDRT regressed on age and start time, RT regressed on navigation method, commission errors regressed on stress, covariance between RT and SDRT. *p < 0.05, **p < 0.01, ***p < 0.001.*

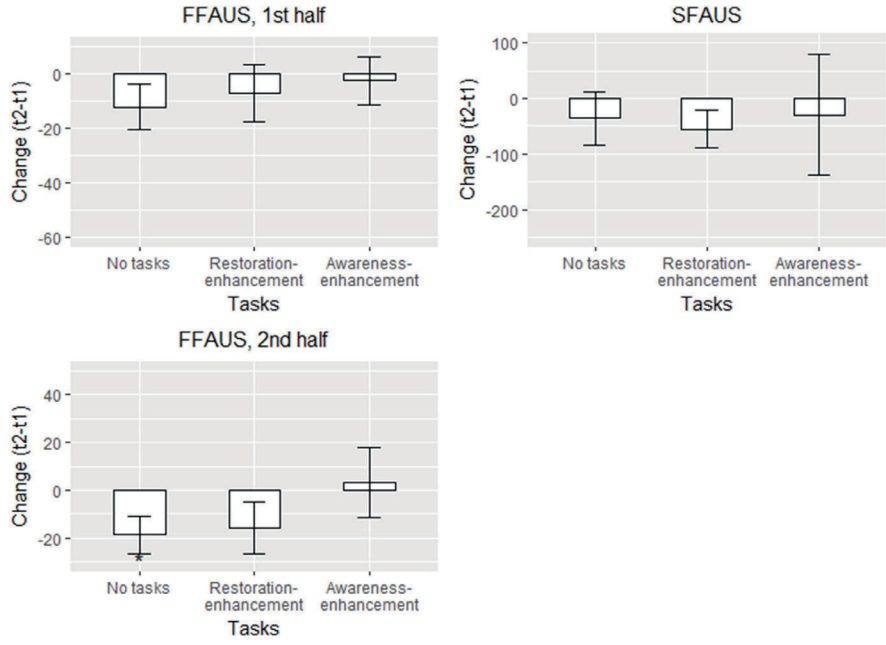

FIGURE 7 | Adjusted means in different conditions for the refined SART variability measures in Study 2 (n = 113). Solid line: statistically significant between-group difference. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

the only substantial difference to the reported model was that more stress predicted less FFAUS also in the 1st half of the test. In the second sensitivity model excluding the participants whose mean RT was > 500 ms, the only substantial difference to the final model was that the participants who conducted the restoration-enhancement tasks showed lower FFAUS in the 2nd half. This result strengthens our conclusion that sustained attention improved in this condition.

Discussion

Consistent with Study 1, self-reported restoration and valence increased after the walk in all conditions. In addition, participants were generally more relaxed after the walk compared to before. No differences between the three groups were found on these self-reported measures, however. In terms of sustained attention performance, the participants who conducted the updated restoration-enhancement tasks made less commission errors after the walk but there was no change in their mean RT or SDRT. This indicates an improvement in response accuracy, attention control, and response inhibition following restoration-enhancement but no effect on their speed or variability in responding. For those who conducted the awareness-enhancement tasks, no changes in sustained attention performance were detected. The participants who did not conduct the tasks made less commission errors but their mean RT slowed significantly more than in the other conditions. They also showed less moment-to-moment variability in responding (FFAUS) in the 2nd half of the SART after the walk. Thus, like Study 1, in terms of sustained attention, conducting the restoration-enhancement tasks resulted in greatest improvements in sustained attention performance, followed by walking without tasks.

Although using the smart phones instead of reading the tasks from signposts improved the procedure from Study 1, some found the smart phones disturbing. Being irritated about having to use the smart phone and resorting to using the map could explain why using the paper map was consistently associated with lower self-reported restoration and increased number of SART commission errors (and, in some groups, faster response time). As we instructed the participants to primarily navigate with the smart phones, unless they found it disturbing, it is plausible that using the paper map was a result of being irritated during the walk. Relatedly, the participants who conducted tasks had to use the smart phone inevitably more throughout the walk: they viewed the tasks' locations, listened to the signals, and read the tasks from the screen. Having to use the smart phone more could have hindered the quality of interaction with the environment, however, our results indicate no such case. The responses between the 'no tasks' and 'restoration-enhancement tasks' conditions were, in fact, very similar with few exceptions.

Both stress and start time were connected to attention restoration but in opposite ways. Later start time was consistently related to more impulsive responding during the SART, that is, faster responding and making more commission errors.

TABLE 7 | The results for multigroup regression models for the refined SART variability measures in Study 2 (n = 113).

		FFAUS, 1st half				FFAUS, 2nd half				SFAUS			
		b	***SE***	***p***	**β**	***b***	***SE***	***p***	**β**	***b***	***SE***	***p***	**β**
Mean difference, estimated	(1) No tasks	−12.26	8.26	0.14	−0.29	−18.71*	7.81	0.02	−0.39	−35.73	48.18	0.46	−0.16
	(2) Restoration-enhancement tasks (U)	−7.15	10.32	0.49	−0.11	−15.81	10.78	0.14	−0.23	−55.58	33.44	0.10	−0.28
	(3) Awareness-enhancement tasks	−2.55	8.72	0.77	−0.05	3.08	14.64	0.83	0.04	−29.77	107.98	0.78	−0.06
Covariates	Stress	−15.88	10.37	0.13	−0.21 /−0.12/−0.20	−25.77*	12.66	0.04	−0.31/ −0.18/−0.20	−52.55	48.73	0.28	−0.14 /−0.13/−0.06
	Start time	−27.29*	11.59	0.02	−0.26/ −0.17/−0.20	6.11	14.57	0.68	0.05 /0.04 /0.03	−38.73/ 90.54/12.57	59.36/ 66.77/111.53	0.51/ 0.18/0.91	−0.07/0.19 / 0.01
	Age	−0.46	0.47	0.33	−0.12/−0.08/−0.09	−0.43	0.51	0.40	−0.10/−0.07/ −0.06	−1.48	2.36	0.53	−0.07/−.08 /−0.03
	Navigation method	0.81	6.85	0.91	0.01/ 0.01/0.01	−15.25/ −12.47/23.09	8.23/ 15.45/15.83	0.06/ 0.42/0.15	−0.24/ −0.12/0.22	12.72	27.98	0.65	0.04/0.04/ 0.02
	Ease of wayfinding	5.91	9.12	0.52	0.07/ 0.07/0.06	3.91	9.18	0.67	0.04/0.04 / 0.02	29.53	36.21	0.42	0.07/ 0.11/0.03
R^2 (conditions 1/2/3)		0.09/0.05/0.06				0.16/0.05/0.08				0.03/0.08/0.004			

*χ^2 = 26.36 (df = 34, p = 0.82), RMSEA < 0.001, CFI = 1.00, TLI = 1.73, SMRM = .08. Grouping is based on the study condition; figures separated by "/" if they differed between the groups. U: updated from Study 1. 3 outliers deleted; parameters freed across groups: FFAUS (2nd half) regressed on navigation method and SFAUS regressed on start time. *p < 0.05, **p < 0.01, ***p < 0.001.*

This could be explained by the circadian rhythm and attention fatigue during the day (Riley et al., 2017), as usually those who participated later came directly after work. Being more stressed in the past 4 weeks was also connected to responding faster but making less commission errors and having less moment-to-moment attentional slips toward the end of the sustained attention test. Thus, the results indicate that participants who were more stressed experienced more sustained attention restoration during the nature walk whereas sustained attention was not restored after participating later during the day (and possibly after work).

It is important to note that even though we found no evidence that the awareness-enhancement tasks improved attention restoration, they were used very differently than in Duvall's original studies (Duvall, 2011, 2013). In these studies, the participants could choose which tasks to use and when; they could change the tasks frequently between or within their walks, or keep on doing the same task during multiple walks. Duvall's intervention (Duvall, 2011, 2013) covered several nature walks during 2 weeks, and it is possible that some restorative effects reported in these interventions may develop over longer time periods because participants may need more time to learn and become used to the tasks (Lymeus et al., 2018).

DISCUSSION

Overall Discussion (Studies 1 and 2)

Our experimental field studies support the established findings that various types of nature visits enhance positive mood but the effects on attention restoration are more nuanced (McMahan and Estes, 2015; Ohly et al., 2016). Although our studies varied in exposure time and environmental quality, the self-reported mood-related outcomes, valence and restoration, showed a similar, positive change. This is in line with meta-analyses summarizing experimental studies on nature exposure (Barton and Pretty, 2010; McMahan and Estes, 2015). Sustained attention improved overall in terms of reduced commission errors; this can indicate less mindlessness and fewer attentional slip-ups in 'real life' (Robertson et al., 1997). The fact that there were fewer differences between self-reported outcomes compared to sustained attention corroborates findings from Lin et al. (2014). In both our studies, the greatest improvements in sustained attention were experienced when the participants conducted the restoration-enhancement tasks ending with instructed relaxation. Less clear, however, is the longevity of these effects, and potential benefits over repeated walks. Repeated exposure to, and engagement with, a natural environment could provide added restoration via place attachment and favorite place establishment (Korpela et al., 2010). We have seen encouraging results showing the attention benefits of repeatedly engaging with the environment via different types of engagement strategies (Duvall, 2011; Lymeus et al., 2018). Whether the psychological tasks examined in our studies could provide similar benefits over a longer course is a matter for future research. Furthermore, as our studies integrated components of different restoration mechanisms (attention restoration, stress reduction, and place attachment), future research investigating the relative contributions of these components in providing restorative outcomes would be worthwhile.

The finding that both mood and sustained attention improved after a nature walk not only supports Stress reduction theory and Attention restoration theory but also the idea that the processes they describe are co-occurring (Kaplan, 1995; Markevych et al., 2017). This was further supported by the strong role of stress prior to, and during, the experiment in explaining both changes in affective and attention restoration. The role of environmental engagement in enhancing restorative benefits of nature exposure, on the other hand, is less clear. We found evidence that restoration-enhancement tasks, aimed to guide interaction with the environment, can aid sustained attention but no indication that it could enhance affective restoration. Furthermore, there was no evidence (in Study 1) that to promote sustained attention, the tasks should follow the theory-based sequence with life reflection at the final stage, or that tasks focusing on engagement without addressing restoration would benefit sustained attention (Study 2; cf. Duvall, 2011). The fact that the contents and the order of the tasks and their congruence with the environment mattered in terms of sustained attention highlights the sensitive and complex nature of person-environment interaction (Kaplan and Kaplan, 1989). Our understanding of these complexities might benefit from qualitative future investigation. Furthermore, although our results suggest that engagement with the environment can be a relevant facilitator of attention restoration, it is, naturally, possible that other type of tasks or forms of engagement could promote both attention and affective restoration more effectively, or, consistently.

Our studies were conducted in the field with a focus on creating a realistic nature visit. It is expected that people respond to these types of psychological tasks differently, and in both our studies, participants could complete them in a way they preferred. Concurrently, this means that we had little control over how 'well' the tasks were conducted, how much time was spent on the tasks, or on the quality of the environmental interaction that the tasks aimed to enhance. To better understand restoration process and the relative contributions of each component in the restoration process – physiological, affective, attentional – it would have been useful to have a measure to assess interaction with the environment during the walk, and not just the restorative outcomes following it. However, examining person-environment interaction without disturbing this interaction could be challenging, and it remains a topic for future studies to explore. Similarly, the fact that the participants could walk at their own pace improved the external validity of the experiment but, at the same time, we could not control for events during the walk (Abrahamse et al., 2016). Had the participants walked in groups, the presence of others, the group size, or inability to walk at one's typical pace may have also affected the experiment in a more positive or negative way (e.g., Staats and Hartig, 2004).

Because the two studied paths differed in environmental type, length, and signing, we conducted no analyses comparing the effects between the studies. Overall, however, the effects of these two similar experiments were to the same direction in all our

measures. This gave us more confidence to draw conclusions, especially when conclusions from the individual studies had to be made with caution due to lower-than-planned sample sizes and, consequently, less power in the statistical analyses. The fact that the findings were similar in the two studies accords with a number of studies and meta-analyses that have found no difference between the restorative effects of wild and maintained natural environments, or otherwise different types of natural environments (Barton and Pretty, 2010; McMahan and Estes, 2015; Rogerson et al., 2016).

Finally, it is important to note that our results may not apply to the general population. Although the samples had the benefit of being more diverse than the commonly used student samples, the participants were mostly female and likely more nature-oriented than the general population. To obtain more diverse samples, similar future studies could try different recruitment methods (such as targeting employees near the study sites) and providing more incentives (such as raffles or more extensive feedback) for participation. Another issue with the samples were drop-outs due to last-minute cancelations and bad weather. The cancelation rates were smaller in Study 2 that, compared to Study 1, was shorter, more easily accessible by public transport, and used an online-calendar for signing up in the study; all these features probably contributed to lower sample attrition and could be recommended for future studies.

CONCLUSION

Our studies focused on the concept of active engagement with the environment, previously receiving scant empirical attention, advancing our theoretical and practical understanding of the restorative environments field. We examined this by designing, and testing, the effects of restoration-enhancement tasks along nature trails. The present studies indicate that these tasks can have a beneficial influence on sustained attention, whereas self-reported restoration and valence appear to improve after a nature walk regardless of conducting tasks. The studies also provide tentative evidence that the effects on sustained attention are sensitive to the tasks' contents: conducting tasks can either hinder or facilitate performance in a sustained attention task compared with regular nature walks without tasks. These findings are in line with both Stress reduction theory and Attention restoration theory, and support the idea that these two theories about attention and affective restoration describe complementary processes (Kaplan, 1995; Markevych et al., 2017).

Most Finnish people regularly spend time in nature, and the most common recreational activity in nature is walking (Sievänen and Neuvonen, 2011). It is also common to visit natural settings for stress reduction purposes and to experience restoration from such visits (Pasanen et al., 2018). Our studies indicate that some aspects of restoration during nature walks could be enhanced by encouraging active engagement with the environment. We already have tentative evidence that self-reported restoration evaluations are similar across visits to nature trails with the same tasks in other European countries (Korpela et al., 2017). Transferring these tasks to other countries and routes is low-cost and requires little-to-no physical environmental modification, and promoting their use has, thus, potentially wider benefits. Moreover, conducting restoration-enhancement tasks or other engagement strategies during a nature walk is free for the public, and it may facilitate interaction with the surrounding environment, especially in cases where natural settings are less optimal, uninteresting or cannot be easily redesigned (cf. Duvall, 2011). Ideally, the tasks could support nature visitors' everyday attention restoration, enhance motivation to visit restorative (natural) settings, and educate or sensitize people who are not familiar with interacting with nature. Restoration-enhancement tasks are, in conclusion, a promising avenue for enhancing the benefits of nature experiences.

AUTHOR CONTRIBUTIONS

This study was originated by KK, who designed and planned the experiments with TP. TP collected the data with a research assistant, conducted the statistical analyses, and wrote the majority of the paper. KJ calculated the variables for FFAUS and SFAUS. KK, KL, and KJ critically revised the manuscript several times. All authors contributed to data interpretation and gave final approval to the version to be published.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.02057/full#supplementary-material

REFERENCES

Abrahamse, W., Schultz, P. W., and Steg, L. (2016). "Research designs for environmental issues," in *Research Methods for Environmental Psychology*, ed. R. Gifford (Hoboken, NJ: John Wiley & Sons, Ltd.), 53–70. doi: 10.1002/9781119162124.ch4

Barton, J., and Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environ. Sci. Technol.* 44, 3947–3955. doi: 10.1021/es903183r

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychol. Bull.* 107, 238–246. doi: 10.1037/0033-2909.107.2.238

Berman, M. G., Jonides, J., and Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychol. Sci.* 19, 1207–1212. doi: 10.1111/j.1467-9280.2008.02225.x

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *J. Environ. Psychol.* 25, 249–259. doi: 10.1016/j.jenvp.2005.07.001

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

Browne, M. W., and Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociol. Methods Res.* 21, 230–258. doi: 10.1177/0049124192021002005

City of Tampere. (2017). *Hatanpään Arboretum*. Available at: https://www.tampere.fi/asuminen-ja-ymparisto/ymparisto-ja-luonto/puistot-ja-viheralueet/puistot/hatanpaan-arboretum.html [accessed February 13, 2018].

Cohen, S., Kamarck, T., and Mermelstein, R. (1983). A global measure of perceived stress. *J. Health Soc. Behav.* 24, 385–396. doi: 10.2307/2136404

de Bloom, J., Geurts, S. A. E., Taris, T. W., Sonnentag, S., de Weerth, C., and Kompier, M. A. J. (2010). Effects of vacation from work on health and well-being: lots of fun, quickly gone. *Work Stress* 24, 196–216. doi: 10.1080/02678373.2010.493385

Duvall, J. (2011). Enhancing the benefits of outdoor walking with cognitive engagement strategies. *J. Environ. Psychol.* 31, 27–35. doi: 10.1080/02699930441000238

Duvall, J. (2013). Using engagement-based strategies to alter perceptions of the walking environment. *Environ. Behav.* 45, 303–322. doi: 10.1177/0013916511423808

Faul, F., Erdfelder, E., Lang, A., and Buchner, A. (2007). GPower 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods* 39, 175–191. doi: 10.3758/BF03193146

Ferguson, C. J. (2009). An effect size primer: a guide for clinicians and researchers. *Prof. Psychol. Res. Pract.* 40, 532–538. doi: 10.1037/a0015808

Gatersleben, B., and Andrews, M. (2013). When walking in nature is not restorative—the role of prospect and refuge. *Health Place* 20, 91–101. doi: 10.1016/j.healthplace.2013.01.001

Gulwadi, G. B. (2006). Seeking restorative experiences. *Environ. Behav.* 38, 503–520. doi: 10.1177/0013916505283420

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., and Gärling, T. (2003). Tracking restoration in natural and urban field settings. *J. Environ. Psychol.* 23, 109–123. doi: 10.1016/S0272-4944(02)00109-3

Hartig, T., Lindblom, K., and Ovefelt, K. (1998). The home and near-home area offer restoration opportunities differentiated by gender. *Scand. Hous. Plan. Res.* 15, 283–296. doi: 10.1080/02815739808730463

Hartig, T., Mang, M., and Evans, G. W. (1991). Restorative effects of natural environment experiences. *Environ. Behav.* 23, 3–26. doi: 10.1177/0013916591231001

Hartig, T., Mitchell, R., de Vries, S., and Frumkin, H. (2014). Nature and health. *Annu. Rev. Public Health* 35, 207–228. doi: 10.1146/annurev-publhealth-032013-182443

Hu, L., and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equ. Modeling* 6, 1–55. doi: 10.1080/10705519909540118

Johnsen, S. ÅK., and Rydstedt, L. W. (2013). Active use of the natural environment for emotion regulation. *Eur. J. Psychol.* 9, 798–819. doi: 10.5964/ejop.v9i4.633

Johnson, K. A., Kelly, S. P., Bellgrove, M. A., Barry, E., Cox, M., Gill, M., et al. (2007). Response variability in attention deficit hyperactivity disorder: evidence for neuropsychological heterogeneity. *Neuropsychologia* 45, 630–638. doi: 10.1016/j.neuropsychologia.2006.03.034

Kaplan, R., and 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. *J. Environ. Psychol.* 15, 169–182. doi: 10.1016/0272-4944(95)90001-2

Kaplan, S. (2001). Meditation, restoration, and the management of mental fatigue. *Environ. Behav.* 33, 480–506. doi: 10.1177/00139160121973106

Kline, R. B. (2016). *Principles and Practice of Structural Equation Modeling. Methodology in the Social Sciences*, 4th Edn. New York, NY: Guilford Press.

Korpela, K., and Hartig, T. (1996). Restorative qualities of favorite places. *J. Environ. Psychol.* 16, 221–233. doi: 10.1006/jevp.1996.0018

Korpela, K., Savonen, E., Anttila, S., Pasanen, T., and Ratcliffe, E. (2017). Enhancing wellbeing with psychological tasks along forest trails. *Urban For. Urban Green.* 26, 25–30. doi: 10.1016/j.ufug.2017.06.004

Korpela, K. M. (2003). Negative mood and adult place preference. *Environ. Behav.* 35, 331–346. doi: 10.1177/0013916503035003002

Korpela, K. M. (2012). "Place attachment," in *The Oxford Handbook of Environmental and Conservation Psychology*, ed. S. Clayton (New York, NY: Oxford University Press), 148–163.

Korpela, K. M., Ylén, M., Tyrväinen, L., and Silvennoinen, H. (2008). Determinants of restorative experiences in everyday favorite places. *Health Place* 14, 636–652. doi: 10.1016/j.healthplace.2007.10.008

Korpela, K. M., Ylén, M., Tyrväinen, L., and Silvennoinen, H. (2010). Favorite green, waterside and urban environments, restorative experiences and perceived health in Finland. *Health Promot. Int.* 25, 200–209. doi: 10.1093/heapro/daq007

Korpela, K. M., and Ylén, M. P. (2009). Effectiveness of favorite-place prescriptions: a field experiment. *Am. J. Prev. Med.* 36, 435–438. doi: 10.1016/j.amepre.2009.01.022

Lee, K. E., Williams, K. J., Sargent, L. D., Williams, N. S., and Johnson, K. A. (2015). 40-second green roof views sustain attention: the role of micro-breaks in attention restoration. *J. Environ. Psychol.* 42, 182–189. doi: 10.1016/j.jenvp.2015.04.003

Lin, Y., Tsai, C., Sullivan, W. C., Chang, P., and Chang, C. (2014). Does awareness effect the restorative function and perception of street trees? *Front. Psychol.* 5:906. doi: 10.3389/fpsyg.2014.00906

Lymeus, F., Lindberg, P., and Hartig, T. (2018). Building mindfulness bottom-up: meditation in natural settings supports open monitoring and attention restoration. *Conscious. Cogn.* 59, 40–56. doi: 10.1016/j.concog.2018.01.008

Manly, T., Owen, A. M., McAvinue, L., Datta, A., Lewis, G. H., Scott, S. K., et al. (2003). Enhancing the sensitivity of a sustained attention task to frontal damage: convergent clinical and functional imaging evidence. *Neurocase* 9, 340–349. doi: 10.1076/neur.9.4.340.15553

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., et al. (2017). Exploring pathways linking greenspace to health: theoretical and methodological guidance. *Environ. Res.* 158, 301–317. doi: 10.1016/j.envres.2017.06.028

McMahan, E. A., and Estes, D. (2015). The effect of contact with natural environments on positive and negative affect: a meta-analysis. *J. Posit. Psychol.* 10, 507–519. doi: 10.1080/17439760.2014.994224

Mitchell, R., and Popham, F. (2008). Effect of exposure to natural environment on health inequalities: an observational population study. *Lancet* 372, 1655–1660. doi: 10.1016/S0140-6736(08)61689-X

Monk, T. H., and Leng, V. C. (1982). Time of day effects in simple repetitive tasks: some possible mechanisms. *Acta Psychol.* 51, 207–221. doi: 10.1016/0001-6918(82)90035-X

Muthén, L. K., and Muthén, B. O. (1998/2012). *Mplus User's Guide*, 7th Edn. Los Angeles, CA: Muthén & Muthén.

Nisbet, E. K., and Zelenski, J. M. (2013). The NR-6: a new brief measure of nature relatedness. *Front. Psychol.* 4:813. doi: 10.3389/fpsyg.2013.00813

Ohly, H., White, M. P., Wheeler, B. W., Bethel, A., Ukoumunne, O. C., Nikolaou, V., et al. (2016). Attention restoration theory: a systematic review of the attention restoration potential of exposure to natural environments. *J. Toxicol. Environ. Health B Crit. Rev.* 19, 305–343. doi: 10.1080/10937404.2016.1196155

Pasanen, T. P., Neuvonen, M., and Korpela, K. M. (2018). The psychology of recent nature visits: (how) are motives and attentional focus related to post-visit

restorative experiences, creativity, and emotional well-being? *Environ. Behav.* 50, 913–944. doi: 10.1177/0013916517720261

Peirce, J. W. (2009). Generating stimuli for neuroscience using PsychoPy. *Front. Neuroinform.* 2:10. doi: 10.3389/neuro.11.010.2008

Pilotti, M., Klein, E., Golem, D., Piepenbrink, E., and Kaplan, K. (2015). Is viewing a nature video after work restorative? Effects on blood pressure, task performance, and long-term memory. *Environ. Behav.* 47, 947–969. doi: 10.1177/0013916514533187

Riley, E., Esterman, M., Fortenbaugh, F. C., and DeGutis, J. (2017). Time-of-day variation in sustained attentional control. *Chronobiol. Int.* 34, 993–1001. doi: 10.1080/07420528.2017.1308951

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., and Yiend, J. (1997). 'Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia* 35, 747–758. doi: 10.1016/S0028-3932(97)00015-8

Rogerson, M., Brown, D. K., Sandercock, G., Wooller, J. J., and Barton, J. (2016). A comparison of four typical green exercise environments and prediction of psychological health outcomes. *Perspect. Public Health* 136, 171–180. doi: 10.1177/1757913915589845

Russell, J. A., and Snodgrass, J. (1987). Emotion and the environment. *Handb. Environ. Psychol.* 1, 245–281.

Russell, J. A., Weiss, A., and Mendelsohn, G. A. (1989). Affect grid: a single-item scale of pleasure and arousal. *J. Pers. Soc. Psychol.* 57, 493–502. doi: 10.1037/0022-3514.57.3.493

Satorra, A., and Bentler, P. M. (2010). Ensuring positiveness of the scaled difference chi-square test statistic. *Psychometrika* 75, 243–248. doi: 10.1007/s11336-009-9135-y

Sievänen, T., and Neuvonen, M. (eds) (2011). "Luonnon virkistyskäytön kysyntä 2010 ja kysynnän muutos," in *Luonnon Virkistyskäyttö 2010 [Outdoor Recreation 2010]*, Vol. 212, (Vantaa: Metsäntutkimuslaitos), 37–73.

Silvennoinen, H., Pukkala, T., and Tahvanainen, L. (2002). Effect of cuttings on the scenic beauty of a tree stand. *Scand. J. For. Res.* 17, 263–273. doi: 10.1080/028275802753742936

Smilek, D., Carriere, J. S. A., and Cheyne, J. A. (2010). Failures of sustained attention in life, lab, and brain: ecological validity of the SART. *Neuropsychologia* 48, 2564–2570. doi: 10.1016/j.neuropsychologia.2010.05.002

Staats, H., and Hartig, T. (2004). Alone or with a friend: a social context for psychological restoration and environmental preferences. *J. Environ. Psychol.* 24, 199–211. doi: 10.1016/j.jenvp.2003.12.005

Staats, H., Kieviet, A., and Hartig, T. (2003). Where to recover from attentional fatigue: an expectancy-value analysis of environmental preference. *J. Environ. Psychol.* 23, 147–157. doi: 10.1016/S0272-4944(02)00112-3

Stigsdotter, U. K., and Grahn, P. (2011). Stressed individuals' preferences for activities and environmental characteristics in green spaces. *Urban For. Urban Green.* 10, 295–304. doi: 10.1016/j.ufug.2011.07.001

Stothart, C. (2015). *Python SART (Version 2) [software]*. Available at: https://github.com/cstothart/sustained-attention-to-response-task

Tabachnick, B. G., and Fidell, L. S. (2014). *Using Multivariate Statistics*, 6th Edn. Boston, MA: Pearson Education, Inc.

Tucker, L. R., and Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika* 38, 1–10. doi: 10.1007/BF02291170

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. *Hum. Behav. Environ. Adv. Theory Res.* 6, 85–125. doi: 10.1007/978-1-4613-3539-9_4

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., and Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *J. Environ. Psychol.* 11, 201–230. doi: 10.1016/S0272-4944(05)80184-7

Västfjäll, D., and Gärling, T. (2007). Validation of a Swedish short self-report measure of core affect. *Scand. J. Psychol.* 48, 233–238. doi: 10.1111/j.1467-9450.2007.00595.x

Wells, N. M., and Evans, G. W. (2003). Nearby nature: a buffer of life stress among rural children. *Environ. Behav.* 35, 311–330. doi: 10.1177/0013916503035003001

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