



Restorative effects of urban green environments and the role of urban-nature orientedness and noise sensitivity: A field experiment

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ABSTRACT

In this experiment we investigated how individual differences in orientation towards built vs. nature environment as well as noise sensitivity affect psychological and physiological restoration in a constructed urban park, urban woodland and city centre of Helsinki, Finland. The participants, 30–61-year-old healthy women (N = 83), visited each study site once. The experiment consisted of a 15-min viewing session, followed by a 30-min walking session in each environment. We measured restorative effects: perceived restorative outcomes, vitality, and blood pressure in these three environments. The data were analysed in SAS with a linear mixed model. We found significant differences between environments in psychological restorative effects, but not in blood pressure. The urban-nature orientedness, and to a lesser extent noise sensitivity, modified the effect of environment on restoration. In conclusion, individual characteristics affect psychological restoration provided by various urban environments. Varying needs of individuals should be taken into account in city planning.

1. Introduction

Research has shown that contact with the natural environment supports human health and wellbeing. In addition to the direct effects of environmental quality (e.g. air and water quality, temperature and provision of protection against heat) (e.g. [Laforteza et al., 2009](#); [Maas et al., 2009](#); [Pugh et al., 2012](#); [Tyrväinen et al., 2005](#)), there is cumulative evidence of the positive effects of nature mainly through stress-amelioration and restoration (e.g. [Hartig et al., 2014](#); [ten Brink et al., 2016](#)). The green spaces have positive effects on mood and cognitive functioning ([Bowler et al., 2010](#); [Bratman et al., 2015](#); [Van den Berg et al., 2003](#)), people prefer nature when emotionally tired ([Korpela et al., 2010](#)), and urban green areas help to reduce attentional stress and enhance psychological recovery (e.g. [Björk et al., 2008](#); [Hartig et al., 2003](#); [Tyrväinen et al., 2014](#)). Of the physiological health effects, the research evidence suggests that being in nature has positive effects on blood pressure, heart rate, skin conductivity, muscle tension and cortisol levels ([Hartig et al., 2003](#); [Horiuchi et al., 2013](#); [Laumann et al., 2003](#); [Park et al., 2010](#); [Tsunetsugu et al., 2007](#)).

The two main theoretical standpoints behind the studies on restorative effects of different environments are the attention restoration

theory ([Kaplan and Kaplan, 1989](#)) and the psychophysiological stress recovery theory ([Ulrich, 1983](#)). The first one poses that the restorative environments allow restoration from directed attention fatigue and thus improvement in cognitive functioning. The potential for restoration exists if psychophysiological resources for coping with everyday demands have been depleted ([Hartig, 2004](#); [Von Lindern et al., 2017](#)). The second one allows recovery from stress through psycho-physiological pathways (e.g. improvement of mood and physiological markers). According to [Kaplan \(1995\)](#), attention and stress are distinct but interacting components of restoration.

In addition to attention restoration and physiological markers of stress, in this study subjective vitality was considered as a related but distinct positive restorative effect related to nature contacts ([Nix et al., 1999](#); [Ryan et al., 2010a, 2010b](#)). In contrast to low energy states (e.g. relaxation), subjective vitality reflects high energy states (aliveness, energy available for self). The evidence shows that nature experiences have a unique effect on vitality ([Ryan et al., 2010b](#)).

The restoration in urban green spaces is suggested to depend on physical characteristics, such as type of vegetation and size of the green area (e.g. [Tyrväinen et al., 2014](#); [Van den Berg et al., 2014](#)). There is evidence that favourite natural-like environments (e.g. woodlands), for

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example, are found to be more restorative than urban parks (Korpela et al., 2010); the more edge vegetation within a forested park screens the view of the built environment, the higher the perceived restorativeness of the area (Hauru et al., 2012). Some field experiments studying restorative effects of urban parks (Beil and Hanes, 2013) or green and blue areas (Gidlow et al., 2016) have not reported differences in the restorative effects of nature areas.

The restorative outcomes in green areas might also depend on individual differences. Even though green areas in general seem to be restorative, little is known about the differences of restorative outcomes between individuals. There is some evidence that not all people perceive nature and its affordances in a similar way (e.g. Faehnle et al., 2014; Tyrväinen et al., 2003) and if so, different urban settings could influence individual restoration differently. The life cycle, situational factors and working environment influence the choice of restorative environments and the restorative effects in these environments. For example, people with health complaints, compared to those with fewer health complaints, are more likely choose natural rather than urban favourite places and in emotional terms benefit more from their visits to these places (Korpela and Ylén, 2009). The motives behind visiting green areas are related to the restorative outcomes, the ones who visit green areas for stress reduction experience restoration more than those who are looking for solitude (Pasanen et al., 2017). People whose work is related to natural environments do not experience as much restoration in these environments as people whose work is not related with nature. For example forest professionals report a lower feeling of restoration after forest visits compared to non-forest professionals (Von Lindern et al., 2013), and children who perform work-like activities in agricultural areas report experiencing fewer restorative experiences than children who spend only their free time in these areas (Collado et al., 2016).

In this study, we hypothesise that individual characteristics, such as urban-nature orientedness and noise sensitivity influence restorative effects in response to green exposures. These individual characteristics are previously shown to be linked partly to genetic predispositions (e.g. general sensitivity (Palmquist et al., 2014)) and personal past experiences (e.g. nature orientedness, Okokon et al., 2015)).

1.1. Urban-nature orientedness

There are concepts for describing individuals' subjective relationship to nature, for example connectedness to nature (Mayer and McPherson Frantz, 2004), nature relatedness (Nisbet et al., 2009) or emotional affinity to nature (Kals et al., 1999). These concepts refer to a deep connection with nature, such as the degree of emotional affiliations and sense of oneness with the natural world and kinship with animals and plants (e.g. Mayer and McPherson Frantz, 2004; Nisbet et al., 2009).

There is evidence that exposure to nature reinforces the nature relationship that is partially suggested to mediate the positive effects of nature, for example mood improvement (Mayer et al., 2009; Gidlow et al., 2016). Nature relatedness is positively correlated with positive affect, vitality, autonomy, personal growth and purpose in life (Nisbet et al., 2011).

In the urban context, green areas are in general appreciated in housing environments. The value of nearby nature is also manifested by the raised property values and it influences location and type of housing choices (Faehnle et al., 2011; Tyrväinen and Miettinen, 2000; Tyrväinen et al., 2005). The relative importance of and expectations towards nature, however, seems to vary between individuals (e.g. Faehnle et al., 2011; Korpela et al., 2010; Tyrväinen et al., 2007a; Tyrväinen et al., 2007b). Linked to this discussion a concept – urban-nature orientedness – has been found useful. Hirvonen (2000), for example, suggests that city dwellers could be categorized into nature- and urban-oriented individuals according to their preferences or affiliations towards natural and built environments. The urban-nature orientedness

focuses on individuals' environmental preferences in the urban context and considers the relative appeal of both constructed and nature environments. Moreover, Tyrväinen et al. (2007b) classified residents in Finnish cities using a measure developed to differentiate among respondents according to the appeal that natural environments hold for them compared to attractions and services of urban environments. The grouping resulted in five classes that explained well the differences linked to housing environment preferences and the choice for housing type. The two extremes in this classification were true urbanites, strongly appreciating urban environments and nearness to services, and true nature people, appreciating peace, safety and nearby nature areas.

In conclusion, exposure to nature seems to affect nature relatedness; also people are shown to value environments and the opportunities in these environments differently. However, there are no studies to show if the appeal towards nature or built-up environments affects the restorative effects in different environments. We want to fulfil this gap and to examine whether the restorative effects vary in different green areas by urban-nature orientedness type.

1.2. Noise sensitivity

Another aspect that might be related to restorative effects in different urban environments is noise sensitivity; a personal trait that is partly genetically determined (Heinonen-Guzejev et al., 2005). Noise-sensitive persons react more negatively and strongly to elevated levels of noise, and also react at lower levels than the rest of the population (Stansfeld, 1992). Noise sensitivity has been reported to be associated with, e.g. hypertension, pulmonary edema (and risk of smoking), cardiovascular mortality, and increased use of painkillers and psychotropic medication (Heinonen-Guzejev et al., 2004, 2007; Shepherd et al., 2010). This may be explained by the association of personal traits such as anxiety and the negative affect with noise sensitivity. On the other hand, noise sensitivity predicts annoyance caused by noise (Okokon et al., 2015; Paunovic et al., 2009) and annoyance may predict effects of noise on health even better than the actual noise level.

The perceived disturbance of traffic is also related to the perceived restorative quality of residential environments that in turn is related to health and well-being (Von Lindern et al., 2016). In the nature conditions even human voice can cause a decrease in cognitive functioning (e.g. memory) (Benfield et al., 2010).

Natural environments may be especially important for noise-sensitive persons, who tend to suffer from stress and anxiety. Visits to natural environments offer quietness, which is rare in urban environments and is most important for this subpopulation. In fact, in a recent Finnish study, high to extreme noise sensitivity was found to be associated also with higher nature orientedness (Okokon et al., 2015). It is not known how the characteristics of green areas influence the psychophysiological effects of visits to these places among noise-sensitive persons. In this study we examine whether the restorative effects in different green environments vary by noise sensitive and noise insensitive people.

1.3. Hypotheses

In our experiment we examine how the urban-nature orientedness and sensitivity to noise are related to restorative effects (perceived restorative outcomes, vitality and blood pressure) in different urban green environments (city centre – control environment), urban park and urban woodland).

The specific hypotheses are:

For people who are more nature oriented (and less urban oriented), the strongest restorative effects (perceived restorative outcomes, vitality and blood pressure) take place in an urban woodland (in the most natural-like urban green environment).

The previous studies have shown that there are no or small differences between different green environments on restoration, therefore we hypothesise that the urban-oriented people are less affected by the

type of the environment. We assume that urban park and urban woodland have equal restorative effects on urban-oriented people (perceived restorative outcomes, vitality and blood pressure).

Taking into account that the city centre is the noisiest and urban woodland the most peaceful environment, we assume that restorative effects (perceived restorative outcomes, vitality and blood pressure) for noise-sensitive people are strongest in the woodland, whereas the city centre has negative restorative effects. Noise-insensitive people are expected to be less affected by the type of environment compared to noise-sensitive individuals. We expect that there are no differences of restorative effects in green areas on noise-insensitive people.

We are not going to make any more specific hypothesis, since there are no previous studies about the effects of noise insensitivity on restoration in different green environments.

2. Method

2.1. Timing and experimental settings

The experiment was carried out in Helsinki, the capital of Finland following typical work days in the autumn of 2011 and 2012 from mid-August until mid-September, and in spring 2012 from the beginning of May until mid-June. In Finland, at this time the leaves are on trees and the general appearance of nature environments is green. By timing the experiment after a regular working day, we aimed to ensure that the participants were in need of restoration to potentiate restorative effects. The temperature in southern Finland, during early and late summer seasons is relatively warm and mosquitos are relatively inactive. The Research Ethics Committee of the Northern Savo Hospital District has approved the study.

The participants visited three different environmental settings on separate days. The settings were: 1) the city centre, representing a built-up environment (control); 2) a constructed urban park, Alppipuisto (20 ha), that is one of the oldest parks in Helsinki; 3) an urban woodland, Keskuspuisto with a total size of 1000 ha, of 60–100-year-old mixed and conifer forests.

Alppipuisto is established in the 19th century, it has a well-designed area with old trees, ponds with fountains, park plants, elements for recreation such as benches, and even a small amphitheater. The level of maintenance of the park is high. The park is situated in between an amusement park and railway tracks. It consist also a rocky area with sightseeing terrace, but in this experiment we used the flat southern area of Alppipuisto, the size of which is about 5 ha.

Keskuspuisto, the urban woodland used in this experiment, is a forested area with a total size of 1000 ha continuing all along from the south of Helsinki to the edge of the city in the north where the experimental site was situated. Keskuspuisto is the most used recreational area in Helsinki around the year. The park mainly consists of 60–100-year-old mixed and conifer forests, the area is rich in different plant and animal species (e.g. elk, fox, black woodpecker, wood warbler). The woodland has been managed for preserving and enhancing landscape, recreation and biodiversity values for decades by the city including small-scale forest management and renewal of the older forests stands outside protected area (City of Helsinki, 2015).

The area used as a control site in the city centre was in the heart of Helsinki. The viewing area was next to the main street (Mannerheimintie). The walking area went along the big traffic- and walking streets, passing museums, shopping and traffic centre. There were only few single street trees in the experimental area. See Fig. 1 for experimental environments and Supplementary material for the route maps in all environments (Figs. SA–SC).

2.2. Sample

The total sample of the whole experiment consisted of 95 participants, but because there were only few men participating in the

experiment, and because blood pressure regulation is different in men and women (Joyner et al., 2016), only the results from women (N = 88) were included in the analysis in this paper. From these 88 women, five were not included in the analysis because they had visited only one experimental site. The final sample of this study consists of 83 women, aged 30–61 years old (M = 48.31; SD = 8.58), of which five visited two experimental sites and all the rest visited all three experimental sites. From the blood pressure analysis, one additional participant was an outlier and excluded from the analysis due to high blood pressure results. Most of the participants came to the experiment after their working day. We chose participants whose place of work was in the Helsinki Metropolitan Area. The volunteers were recruited through invitation letters sent to personnel managers of different governmental and municipal organizations, and the invitation letter was also published in the monthly bulletin of the University of Helsinki. The invitation letters were also delivered directly to households located nearby the experimental meeting point at the National Institute for Health and Welfare. Some participants could include their participation in this experiment into their working-hours. The average amount of working hours were 38 per week (SD = 13.4). The volunteers had their first personal contact with researchers and their suitability for this experiment was confirmed (e.g. health condition, working in Helsinki Metropolitan Area). Then, the extended information package and the first background information questionnaire were sent by post to volunteers. The guiding sheet informed participants about how to prepare for each visit (no alcohol and tobacco consumption before the experiment, avoidance of hard physical training during the day of the experiment, and some guidance for clothing), how to find the meeting point, and the exact dates and times of all three visiting times.

2.3. Experimental procedure

The participants came to the experiment three times after work at 3 p.m. and the experiment lasted approximately three hours. There was at least one week in between visiting different settings and the order of visiting each study site was randomized. On the first visit, participants also signed a written consent of their voluntary participation and returned questionnaires sent to them prior to the experiment. After arrival at each of the three visits, participants completed a short questionnaire concerning possible recent acute illnesses, medication use, caffeine consumption and active physical training. Then the participants themselves conducted control blood pressure measurements at the meeting office, and wore the same ambulatory blood pressure monitors during the experiment. Participants were divided into groups with a maximum of four people. The group size was determined by the comfortable sitting space in the van. The dates were chosen by the participants so that the experimental days would fit to their timetables, and there were no strict restrictions that the participants in the group could not know each-other. The people in the groups varied, as there were cancellations and changes of times. The trip to the experimental site took 20–30 min by van, the travel time to each site at each day was fixed, and small variation in time was dependent on the situational traffic conditions. After arrival to the experimental site, the participants took the first blood pressure measure and completed the first questionnaire in the van. After that they moved from the van to the site and at first they were asked to sit and look freely at the environment. After the 15-min viewing session in the environment, the second blood pressure measurements and questionnaire were done after sitting at the site. The viewing session was then followed by a 30-min guided speed-controlled slow walk in the environments guided by the experimenter. The routes were predefined and were all approximately 2-km long. The third blood pressure measurements and questionnaire were done in the van after walking. The blood pressure was measured after sitting quietly in the van for three minutes. During the experiment, the researcher carried data loggers for air temperature (and humidity). See Figs. 2–4 for viewing and walking sessions in different environments.



Fig. 1. Experimental environments and meeting points (contains data from the National Land Survey of Finland Background map series, accessed 06/2018). <https://kartta.paikkatietoikkuna.fi/published/en/8faad511-b528-4217-92ff-6b6c75cf9e77>.



Fig. 2. Viewing session in Helsinki city centre.



Fig. 3. Walking session in Alppipuisto (urban park).

The weather varied mostly from sunny to cloudy and a little rain on eight days of the experiment. Average temperatures varied between 23.1, 22.1, and 22.0 °C during the 2011 autumn, 2012 spring, and 2012 autumn experimental periods, respectively. Environmental noise levels were measured with class II Larson Davis Spark 706 noise dosimeters (PCB Piezotronics Inc., Depew, New York, USA) with Larson Davis MPR001 integrated microphone/preamplifiers. The noise level in city centre was 67.6 dBA (SD 2.6), in urban park 63.5 dBA (SD 1.8) and in urban woodland 58.8 dBA (SD 1.5), and the noise levels in all environments were significantly different.

2.4. Materials of this study

2.4.1. Background variables

In addition to basic information (age, family situation, current living environment, etc.) the participants were asked information about their general health, visits to green areas, and work stress by questionnaire sent to their homes before coming to the experiment. Perceived general health status was measured with a widely used single item ‘How is your health in general at the moment?’ using a five-point rating scale ranging from 1 (poor), 2 (quite poor), 3 (neither poor nor good), 4 (quite good) to 5 (excellent) (Singh-Manoux et al., 2006). Physical health status was



Fig. 4. Completing questionnaires in Keskusuisto (urban woodland).

measured with the question ‘How is your physical health at the moment from 1 (very bad), 2 (rather bad), 3 (satisfactory), 4 (rather good) to 5 (very good)?’. For getting background information about the outdoor recreation habits and visits to green areas the following questions were posed: ‘How often do you visit natural or green places in Helsinki Metropolitan area during summer/warm season (May to Sept.) and winter/cold season (Oct.– April) (every day, 4–6 times per week, 2–3 times per week, once a week, 1–3 times per month, less often)?’. The general work stress was measured by one question ‘How stressful/mentally tiring is your job or studies by your evaluation on average?’ followed by five-point Likert scale (not at all, somewhat, rather stressful, very stressful, extremely stressful). The level of work stress was additionally measured by one question on the experimental day: ‘How stressful or tiring was your working-day?’ (I was not working today, not at all, somewhat, rather stressful, very stressful, extremely stressful).

2.4.2. Dependent variables

For measuring restorative effects we used two self-reported scales and blood pressure measures.

2.4.2.1. Psychological measures. We used the Restoration Outcome Scale (ROS) (Korpela et al., 2008; cf. Hartig et al., 1998; Staats et al., 2003) to measure perceived restorative outcomes, and Subjective Vitality Scale (SVS) (Ryan and Frederick, 1997) to measure perceptions of vitality in environmental settings. The participants answered the question: ‘To what extent do the following statements correspond to your current emotional state?’ The ROS scale has six items, of which three reflect relaxation and calmness (e.g. ‘I feel restored and relaxed’), one reflects attention restoration (‘I feel focused and alert’), and two reflect clearing one’s thoughts (e.g. ‘I can forget everyday worries’). Four items out of six original items (Bostic et al., 2000) were used to measure self-reported perceptions of having energy and feelings of being alive (e.g. ‘I feel alive and vital’) from the Subjective Vitality Scale (SVS). In Finland, due to the synonymous nature of the scale items and the words available in the Finnish language we used only four items in our questionnaire. The Subjective Vitality Scale has shown both high reliability and covariation with somatic and psychological factors (Bostic et al., 2000; Ryan and Frederick, 1997). The participants responded with a seven-point Likert scale ranging from not at all to completely.

2.4.2.2. Physiological measures. We measured systolic and diastolic blood pressure with an oscillometric blood pressure monitor (Model 90207, Spacelabs Healthcare, Snoqualmie, WA, USA). Before leaving to an experimental site, a cuff was wrapped around the left arm of the participant. An air hose connected the cuff to the blood pressure

monitor, which was carried in a case attached to a belt (or belt strap) and shoulder strap.

Blood pressure was measured in a sitting position from the left arm resting on a person’s lap. Before a reading was taken, study participants sat still for at least three minutes. At a researcher’s request the participant pushed a button starting the measurement. A second measurement was taken 60 s after the first measurement was finished. In the analyses, the average of the two measurements was used.

2.4.3. Grouping variables

We used an urban-nature orientedness scale to measure the attractiveness towards nature or a city environment previously developed and used in Finnish studies (e.g. Tyrväinen et al., 2007b). The urban-orientedness subscale in this study included four items (e.g., ‘I enjoy hanging around in the city’, ‘I appreciate very much the areas with cafeterias, shops, restaurants, museums, and theatres’) and the nature-orientedness included five items (e.g., ‘sometimes I feel compelled to visit nature’, ‘urban green areas are not sufficient to satisfy my need for nature’), using a five-point rating scale ranging from 1 (completely disagree), 2 (somewhat disagree), 3 (neither disagree nor agree), 4 (somewhat agree) to 5 (completely agree). The groups based on the urban-orientedness subscale were used in this study (see the reason in the Section 3.1).

Weinstein’s (1978) noise sensitivity scale is the most widely used method to assess noise sensitivity. Noise sensitivity was measured by four items excerpted from the 21-item scale followed by seven-point Likert scale from not at all to completely (‘I get irritated when my neighbours make noise’, ‘I am good at concentrating no matter what happens around me’, ‘It is difficult for me to relax in a noisy place’, and ‘I am sensitive to noise’). The basis for the selection of the items is their relative context independence. In addition, the last item is significant because self-estimated sensitivity has been reported to correlate well with the results from the full Weinstein scale in the adult Finnish population (Heinonen-Guzejev et al., 2004).

Temperature was measured continuously with Escort iLog EI-HS-D-32-L data loggers (Cryopak, Quebec, Canada). Researchers assessed the weather before each viewing and walking period, and after the walking period. Categories used to record the weather were: sunny, partly cloudy, cloudy, drizzle. The experiment was cancelled if there was heavy rain. During the whole experimental period only once was the experiment postponed because of this.

2.4.4. Statistical analysis

We conducted linear mixed model analysis with the repeated model option to calculate the effects of intervention in three different urban environments. In the analysis we used a within-subject factor (area type) with three levels (Helsinki city centre (City), Alppuisto (Park) and Keskusuisto (Forest)) and three measurement points (at the start (T1), in the middle (T2) and at the end of the experiment (T3)) for the psychological and physiological outcome variables. These outcome variables were the Restoration Outcome Scale (ROS), Subjective Vitality Scale (SVS) and, systolic and diastolic blood pressure. We used the model type CS (Compound-Symmetry) which specifies the compound-symmetry structure with constant variance and constant covariance. Participants act as their own controls when the effects of different areas are compared.

We calculated separate models for each group based on outcome variables. In the models, the reference point was City at Time 1. All models were controlled for mean Temperature (continuous variable) and Weather (categorical variable) because uncomfortable weather conditions might affect restoration and relaxation, and air temperature is also directly related to blood pressure. For the analysis we used IBM SPSS Statistics 20 and SAS 9.3 packages.

3. Results

3.1. Background information, scale statistics and grouping variables

Most of the volunteers in the experiment evaluated themselves as generally ($M = 4.2, SD = 0.7$) and physically healthy ($M = 4.7, SD = 0.7$). They lived in the Helsinki Metropolitan Area (except five participants). Most participants were active users of urban green areas and visited green areas at least 2–3 times per week (82% during summertime and 59% wintertime) or at least once a week (9.6% summertime and 21.7% wintertime). There were only a few participants who visited nature areas 1–3 times a month or less during summertime (8.4%) and a little more in wintertime (18.6%). The general work stress in our sample was not very high ($M = 2.4, SD = 0.8$). We also asked about work stress on the day of the experiment. However, there were rather many missing values in the questionnaire concerning work stress on the day of the experiment: of the respondents 21–22% on different experimental days did not answer to that question at all and in addition, 7–8% of participants were not working on different experimental days. Therefore, we excluded work stress from our final statistical model. Before visiting any of the three environments, 21.7% of participants evaluated their work stress as ‘rather’ or ‘very stressful’ in the City, 18% in the Park, and 15.6% in the Forest. Among those participants who were working on that day, there was no significant difference in work stress level between City, Park and Forest environments at the start of the experiment in a given environment ($\chi^2(6) = 6.01, p > .05$).

The scale statistic of the Restoration Outcome Scale and Subjective Vitality Scale was good throughout the experiment (see Table 1).

The distributions of nature-orientedness and urban-orientedness subscales were compared to a representative sample of the two biggest Finnish cities (Helsinki and Tampere) (Tyrväinen et al., 2007b) to check whether volunteers in our study were biased towards nature orientedness. In the study by Tyrväinen et al. (2007b), the participants were divided into different subgroups based on a score in nature-orientedness subscale and urban-orientedness subscale as high, medium or small. In the current study, the difference between these subgroup-specific proportions was tested by applying two independent proportions test assuming normal approximation. A significant difference in proportions in ‘ordinary nature people’ ($z = 17.1, p < .01$), and ‘other’ groups ($z = 7.3, p < .01$) was found in our sample. It is possible to conclude that there were more people oriented to nature in our sample than in the previous urban population Helsinki–Tampere sample. Consequently, we chose the urban-orientedness subscale for our grouping variable to provide enough individual variation.

For urban-orientedness and noise sensitivity, the scale statistics and mean sum scores were calculated before dividing respondents into separate groups. For urban-orientedness the scale statistics were Cronbach $\alpha = 0.76, M = 3.21, Mdn = 3.24, SD = 0.89$ and for noise sensitivity Cronbach $\alpha = 0.75, M = 4.2, Mdn = 4.25, SD = 1.08$. The correlation between variables was 0.04 ($p = 0.74$). The respondents

were divided into urban-orientedness and noise sensitivity groups based on the median.

Firstly, the participants were divided by their high or low urban orientedness. In the low-urban-oriented group were 41 participants and in the high-urban-oriented group 42 participants. However, the groups divided by their urban-orientedness dimension differentiated also significantly by their nature-orientedness dimension ($t(80) = 4.9, p < .00$); where in the low-urban-oriented group the nature-orientedness mean score was 4.1 ($SD = 0.53$) and in high-urban-oriented group it was 3.4 ($SD = 0.67$).

Secondly, the participants were divided into two groups by their high or low noise sensitivity. The noise-sensitive group included 47 participants and in the noise-insensitive group there were 36 participants.

3.2. Restorative effects, urban-nature orientedness and noise sensitivity

All models, based on the linear mixed model analysis, were significant according to model fit indexes, and the χ^2 of all models was significant at $p < .01$ level. The descriptive statistics and goodness of fit indexes are presented in Supplementary materials (see Tables SA–SB). The statistical significance of the main effects and interactions of the models are presented in Table 2. In a majority of psychological measures models, the interaction of Environment and Time was significant. None of the interactions were significant on blood pressure measures.

3.2.1. Results by groups and self-reported measures (ROS, SVS)

3.2.1.1. Urban-orientedness. In the low-urban-oriented group, there was a significant interaction effect of Environment and Time on ratings of the restorative outcomes (ROS) and subjective vitality (SVS) scores (see Table 2). In this group, Forest and Park had significantly more positive effect on perceived restoration and feelings of vitality already after 15 min sitting compared to the City. At the end of the experiment, Forest was significantly more restorative and vitalizing than Park (see Figs. 5 and 6, and Table C (supplemental)). In addition, the ROS and SVS scores decreased significantly in City during the experiment. For the ROS, the decrease was significant already after 15 min sitting (Time 2 vs. Time 1 $t(154) = -2.54, p < .05$; Time 3 vs. Time 2 $t(154) = -2.57, p < .05$). For the SVS the decrease was significant at the end of the experiment (Time 3 vs. Time 2 ($t(154) = -3.08, p < .01$), and Time 3 vs. Time 1 ($t(154) = -3.507, p < .01$)). The additional interaction effects of Time are presented in Table SE (supplemental).

In the high-urban-oriented group, only main effects were significant. The significant main effect of Environment on ratings of the restorative outcomes (ROS) showed that Forest and Park were experienced as more restorative compared to City. The effect of Time showed that there were more perceived restorative outcomes in the middle and in the end of the experiment compared to the start. The vitality scores

Table 1
Scale statistics of Restoration Outcome Scale and Subjective Vitality Scale in three places during the experiment.

Place	City Scale statistics			Park			Forest		
	Mean	SD	Cron α	Mean	SD	Cron α	Mean	SD	Cron α
At the beginning									
ROS	4.63	0.93	0.89	4.71	0.84	0.89	4.71	0.88	0.90
SVS	4.68	1.09	0.87	4.71	0.86	0.81	4.74	1.01	0.86
After viewing									
ROS	4.45	0.99	0.87	5.16	0.84	0.88	5.14	0.98	0.61
SVS	4.70	0.94	0.86	4.96	0.83	0.79	4.86	0.97	0.88
After walking									
ROS	4.29	1.03	0.88	5.10	0.93	0.91	5.24	0.85	0.89
SVS	4.48	1.01	0.83	5.06	0.86	0.82	5.12	0.88	0.88

Table 2
Main effects and interactions of all models (degrees of freedom, F-test and level of significance).

Group	Low-urban-oriented		High-urban-oriented		Noise-sensitive		Noise-insensitive	
	df	F	df	F	df	F	df	F
ROS								
Environment	(2, 77)	40.23**	(2, 78)	10.23**	(2, 88)	30.33**	(2, 67)	12.94**
Time	(2, 80)	1.78	(2, 82)	7.51**	(2, 92)	6.63**	(2, 70)	1.16
Env*Time	(4, 154)	11.02**	(4, 156)	1.96	(4, 176)	7.18**	(2, 134)	2.57*
Weather	(3, 37)	2.18	(3, 41)	2.24	(3, 48)	4.10*	(3, 30)	0.43
Temp.	(1, 307)	7.43**	(1, 312)	0.40	(1, 358)	3.99*	(1, 267)	0.06
SVS								
Env	(2, 77)	21.97**	(2, 78)	1.85	(2, 88)	15.95**	(2, 67)	2.18
Time	(2, 80)	2.22	(2, 82)	5.29**	(2, 92)	3.78*	(2, 70)	1.48
Env*Time	(4, 154)	5.66**	(4, 156)	1.43	(4, 176)	3.62**	(4, 134)	2.54*
Weather	(3, 37)	1.87	(3, 41)	1.99	(3, 48)	2.86*	(3, 30)	0.89
Temp.	(1, 307)	1.06	(1, 312)	2.27	(1, 352)	0.05	(1, 267)	0.70
SYS								
Env	(2, 76)	8.80**	(2, 76)	2.61	(2, 88)	1.86	(2, 64)	1.69
Time	(2, 80)	6.74**	(2, 80)	2.30	(2, 92)	5.46**	(2, 68)	2.22
Env*Time	(4, 144)	1.49	(4, 143)	1.00	(4, 169)	1.37	(4, 118)	0.81
Weather	(3, 37)	1.86	(3, 40)	1.62	(3, 48)	2.55	(3, 29)	3.49*
Temp.	(1, 296)	3.52	(1, 295)	4.61*	(1, 345)	1.39	(1, 246)	4.79*
DIA								
Env	(2, 76)	2.90	(2, 76)	6.96**	(2, 88)	2.20	(2, 64)	4.24*
Time	(2, 80)	0.89	(2, 80)	3.95*	(2, 92)	0.75	(2, 68)	5.46**
Env*Time	(4, 144)	0.70	(4, 143)	0.73	(4, 169)	1.22	(4, 118)	0.41
Weather	(3, 37)	1.20	(3, 40)	2.99*	(3, 48)	1.81	(3, 29)	10.9**
Temp.	(1, 296)	6.19*	(1, 295)	7.17**	(1, 345)	3.69	(1, 246)	5.68*

* $p < .05$.

** $p < .01$.

(SVS) were significantly higher at the end of the experiment compared to the start and in the middle of the experiment (see Fig. 6 and Table SC (supplemental)).

3.2.1.2. Noise sensitivity. In the noise-sensitive and noise-insensitive groups, the interaction between Environment and Time had significant effects on restorative outcomes (ROS) and subjective vitality (SVS) scores (see Table 2). After sitting, Forest and Park compared to City were perceived as significantly more restorative (ROS) in both groups, but the subjective vitality score (SVS) at Time 2 was higher only in noise-sensitive group. In both groups, restorative outcomes and subjective vitality scores were higher in Forest and Park compared to City at the end of the experiment (see Figs. 7 and 8, and Table SD, supplemental).

In addition, the perceived restorative outcomes (ROS) in City

decreased significantly during the experiment (Time 3 vs. Time 2 $t(176) = -2.21, p < .05$; Time 3 vs. Time 1 $t(176) = -3.21, p < .01$) among noise-sensitive group. Also, perceived restorative outcomes in Forest were higher in this group already in the middle of the experiment (Time 2 vs. Time 1 $t(176) = 3.56, p < .01$), while there was no such difference among the noise-insensitive group. However, in the noise-insensitive group, Park at Time 2 was experienced as more restorative than park at Time 1 $t(134) = 2.23, p < .05$ (see Table SE, Supplemental).

3.2.2. Results by groups and blood-pressure

The experimental effects on blood pressure, our marker for physiological restoration, were not as straightforward as the results from the psychological measures. None of the interactions between environments and experimental time were significant in the current study

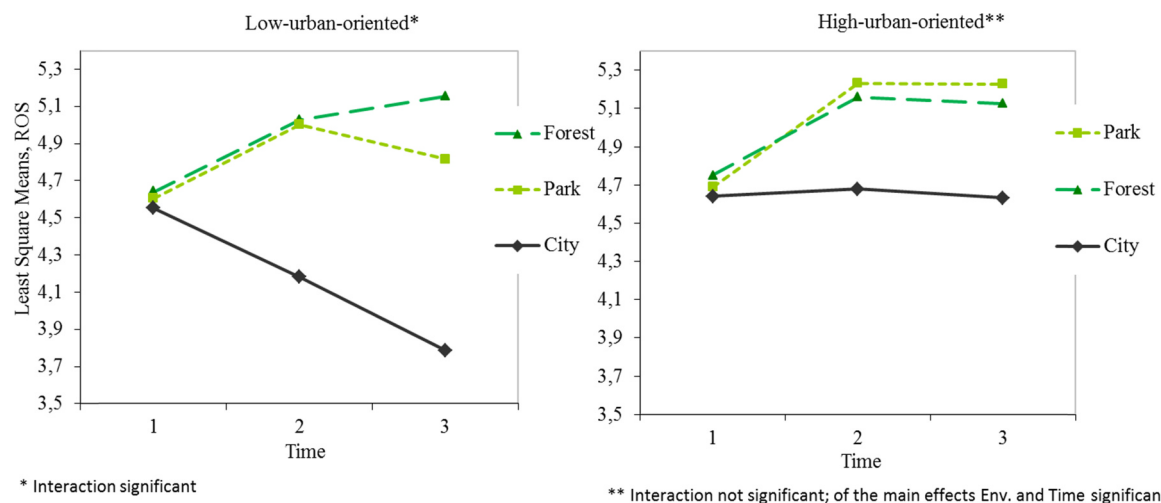


Fig. 5. Graphic representation of least square means of perceived restorative outcomes measured by Restoration Outcome Scale (ROS) by low- and high-urban-oriented groups.

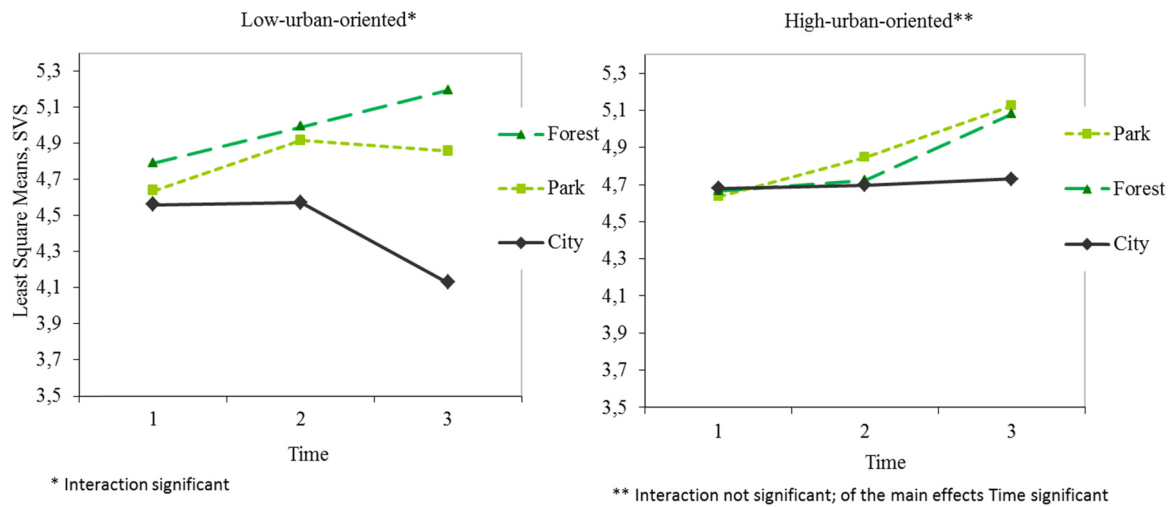


Fig. 6. Graphic representation of least square means of feelings of vitality measured by Subjective Vitality Scale (SVS) by low- and high-urban-oriented groups.

(see Table 2), and blood pressure was not the lowest after entering the green areas as expected. In contrast, the blood pressure was highest in the middle of the experiment, after sitting and viewing the environments. As the blood pressure results were not consistent, for saving space, the full material about blood-pressure results by groups are presented in Supplementary material F.

4. Discussion and conclusions

In this study, we examined the effect of urban-nature orientedness and noise sensitivity on restorative effects (perceived restorative outcomes, vitality, and blood pressure) in different urban environments: city centre (control), urban park and urban woodland. We assumed that participants differing in their urban-nature orientedness and noise sensitivity differ in the strength of restorative effects in different environments. The previous experimental studies have indicated only a small or no difference between different green areas on people's well-being, such as perceived restorativeness, cognitive functioning, or mood change (e.g. Van den Berg et al., 2014; Gidlow et al., 2016). In a study where the tended forest was found to be more restorative than wild forest (Martens et al., 2011), the individual differences were not measured.

As in several previous studies, we found that short-term visits to urban nature areas have positive, temporally progressive effects on psychological well-being (e.g. Tsunetsugu et al., 2013; Van den Berg

et al., 2014) and as hypothesized, there were some specific differences between groups. The results from blood pressure measures were not that consistent.

According to the background measures, the study volunteers (all women) were relatively active users of green areas. There were also more nature-oriented people in our sample, than in the representative sample of Helsinki-Tampere study (Tyrväinen et al., 2007b). We calculated low-urban-oriented and high-urban-oriented groups according to the median in original urban-orientedness dimension. However, in our experiment the high-urban-orientedness should be understood as a relative measure within the study group.

Of all groups (the sample divided firstly by low-/high-/urban-orientedness and then by noise in/sensitivity), the low-urban-oriented group was the most sensitive to the type of the environment over time and explained differences between groups even better than the noise sensitivity. As hypothesized, the highest restorative effects of psychological measures (perceived restorative outcomes (clearing one's thoughts, getting restored and relaxed), and vitality) in the low-urban-oriented group were found in urban woodland at the end of the experiment. In the case of noise sensitivity, there was no significant difference between urban park and urban woodland. Being in the city centre lowered perceived restorative outcomes in the low-urban-oriented and noise-sensitive groups, but feelings of vitality lowered only in the low-urban-oriented group.

The high-urban-oriented and noise-insensitive people were less

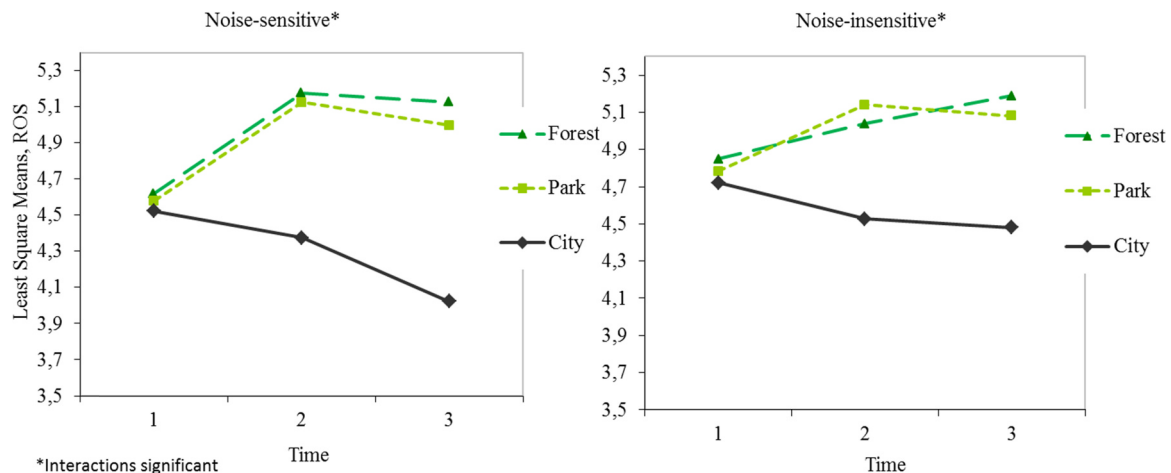


Fig. 7. Graphic representation of least square means of perceived restorative outcomes measured by Restoration Outcome Scale (ROS) by noise-sensitive and noise-insensitive groups.

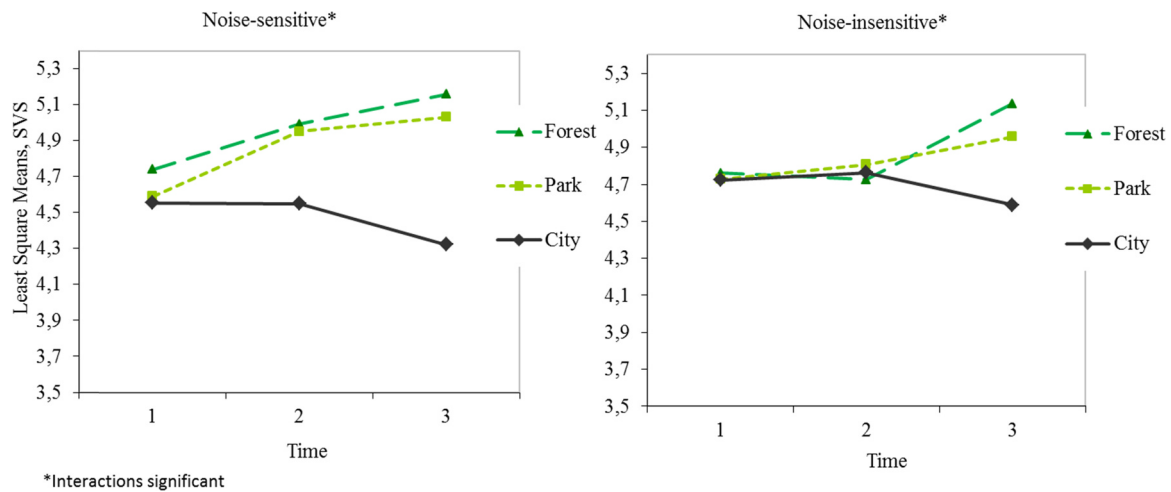


Fig. 8. Graphic representation of least square means of feelings of vitality measured by Subjective Vitality Scale (SVS) by noise-sensitive and noise-insensitive groups.

sensitive to different types of environments in terms of temporal changes in their responses, and there was no difference between green areas. However, somewhat stronger positive psychological effects were evident in nature areas compared to the city centre even among these groups.

The results show that perceived restorative outcomes measured by Restoration Outcome Scale (ROS) and subjective vitality measured by Subjective Vitality Scale (SVS) are different although complementary phenomena as suggested by Ryan et al. (2010b). However, the differences were rather subtle. Within the low-urban-oriented group, the city centre diminished feelings of vitality only at the end of the experiment, and not already after viewing as with the perceived restorative outcomes. In high-urban-oriented group, the green environments raised feelings of restoration, but only time was significant factor for the raise of vitality. Within low-urban-oriented group, the results conform with those by Ryan et al. (2010b) that showed the presence of nature and nature elements mediating the effect of outdoors on vitality.

An additional interesting physiological effect appeared. We had hypothesized that urban park and urban woodland might be equally restorative environments for high-urban-oriented people. Based on the results, blood pressure was the lowest in the urban park (and not in the woodland) among this group and also in noise-insensitive group. However, the effects seemed to have started already before the experiment.

Furthermore, the experimental effects on blood pressure, our marker for physiological restoration, were not as straightforward as the results from the psychological measures. This is in line with previous studies which have reported contrasting results on blood pressure (Hartig et al., 2003; Lee et al., 2014; Park et al., 2009; Tsunetsugu et al., 2007). None of the interactions between environments and experimental time were significant in the current study, and blood pressure was not the lowest after entering the green areas as expected. In conclusion, the hypothesis that green areas decrease blood pressure and urban woodland even more in low-urban-oriented and noise-sensitive groups was not confirmed.

The experiment consisted of two parts – sitting and walking. The participants had been sitting quietly in the van for almost half an hour before arriving at the site and had taken blood pressure measurements in the van before entering to the actual environment. The higher blood pressure measures after sitting and viewing the setting could be due to the observed new environment, environmental stimuli (mosquitos, exposure to wind and sun), other people passing by, as well as sudden activity (taking the commands and pressing the monitor button) that all might have an effect on blood pressure measures. The walking activity after sitting (physical activity) might also explain why there is no difference between the start and the end of the experiment on blood

pressure in different environments since the activities raise blood pressure and can mask the effects of environments. In addition, the participants knew which of the three environments they were going to visit, and it seems that there was an anticipation effect – there were substantial differences between environments in blood pressure measures in the beginning of the visits (the lowest blood pressure in the woodland among the low-urban-oriented group and in the park among the high-urban-oriented and noise-insensitive group). Although there is some evidence showing that people underestimate the strength of positive affect before their nature walks, such results depend on the sample and the urban environments used for comparison (Nisbet and Zelenski, 2011); woodland and park walks have high positive expectancy value in the Finnish culture.

It would be important to study further and to elaborate more upon the effects of the exposure of environmental noise and pollution together with the effects of environmental preferences on restoration in urban green areas. It is hypothesized that physiological changes associated with visits to nature may partly be due to reduced exposure to air pollution and noise. It is known that the cardiovascular system reacts rapidly to environmental exposures (Lanki et al., 2007; Tassi et al., 2010). The physiological stress reactions to noise are partly unconscious and are manifested by higher blood pressure, cortisol, and heart rate variability (Huang et al., 2013; Selander et al., 2009; Van Kempen and Babisch, 2012). The possible effects of environmental preferences on human physiology are less known.

There are some limitations in our study. First, the inclusion of only women limits the generalizability of our results. As women seem to volunteer more readily, in the future, special efforts should be made to recruit men. Second, we do not know the degree of permanence of the effects of visits to different urban areas. Our study did not include a follow-up and we were not able to follow the volunteers after the experiment. Third, most of our participants were active users of nature. It is difficult to know how this affects the results of the experiment. Fourth, our volunteers had to leave work a few hours earlier than on a normal working day because of the timing of the experiment. We had to start relatively early due to taking into account the changes in daylight during the experimental period. This could mean that these participants, who were very busy, and possibly high in occupational stress did not take part in the experiment. Still, this would mean that the restorative outcomes could be even higher for those people who suffer more from resource depletion (such as attention restoration, feelings of stress). Fifth, the experimental setting is not very natural (exact timing of sitting and walking, the same sitting position, walking at a given speed on a given course) and probably influences the results (e.g. blood pressure that is the most sensitive measure). Sixth, before the first and second set of blood-pressure measurements the participants had been

sitting still long before the measure (in the van and after viewing) whereas after walking session the sitting-time was shorter than recommended (Nikolic et al., 2014). However, our conclusions concerning differences in blood pressure in different environments between groups would not have changed as we followed the same protocol in all environments and in all measurement times.

4.1. Applicability of this study

More than 70% of the population in the European Union (Eurostat and Statistics on European Cities, 2016) and more than 50% of all humans worldwide (United Nation and World Urbanization Prospects, 2014) are nowadays living in cities and the challenge is to construct an environment that would support wellbeing for all urban inhabitants. The variety between different subgroups in responses to nature is underexplored (Hartig et al., 2014). Insight related to individual differences in experienced wellbeing effects of urban nature areas helps in identifying the needs of various user groups and encourages taking these differences into account in planning and design of urban green areas.

The preference studies have shown that environmental preferences depend on the expectations and previous experiences about particular environment (e.g. Faehnle et al., 2014; Tyrväinen et al., 2007a). This study showed that next to noise sensitivity, which is already a recognized factor linked to health problems and demands on environmental quality, urban-nature orientedness is another factor that is worth further study. The larger green areas, the urban woodland in our study, fulfil the needs of residents who are less oriented towards the urban environment. This effect might be even larger among the general urban population compared to the small experimental sample. In contrast, the constructed urban parks (together with larger green areas) fulfil the needs of people who are more oriented towards city life and/or are not that sensitive to noise.

In city planning one should aim at securing the provision of larger entities of green areas and avoid fragmentation of urban nature into increasingly smaller units. Larger areas provide amenities such as possibilities for nature experiences and relative quietness in urban environments (e.g. Pietilä et al., 2015; Tyrväinen et al., 2007a). Moreover, noise and air pollution exposure are the lowest in larger units of green areas and may provide physiologically measured health benefits (Lanki et al., 2017). The result that the larger urban green areas can contribute to perceived restorative outcomes and vitality for all studied subgroups mean that these areas should be close to working places or homes, and that people could use them often without special effort to reach them. The availability of green areas is then an issue of equality in society (e.g. Mitchell and Popham, 2008) and the best restorative areas should not be accessible only to a limited number of people. The result that about 45 min of nature exposure in total with slight activity (viewing the environment and slow walking) is even more effective in some groups, also supports the importance of accessibility to larger green areas. The importance of large green areas does not exclude the importance of the design features of smaller urban parks that deserve further study, particularly in relation to different population subgroups (e.g. Nordh et al., 2009). More evidence-based design is also needed in planning and designing green areas for salutogenic environments (Africa et al., 2014).

Thus, walks in green spaces might be fruitfully used in order to promote employee well-being as our positive results on restoration were evident after a working day. Research on work and organizational psychology has so far shown that recovery activities after work such as nature walks, including experiences of detachment from work and relaxation, predict mood improvement, employee well-being and better job performance (Korpela and Kinnunen, 2011; Ryan et al., 2010b; ten Brummelhuis and Bakker, 2012). If and how the restorative effects of nature are related to the individual differences such as familiarity with the environments, the possibility of being away from everyday

demands, and job characteristics (e.g. Von Lindern et al., 2013) requires further study in the future.

In summary, the present study suggests that there are significant differences between adult population subgroups in how efficiently they experience restoration and gain vitality in different environments. It is intuitively easy to grasp that, e.g. low-urban-oriented persons may benefit more from visits to green environments, but to our knowledge this is the first study to investigate how urban-nature orientedness and noise sensitivity are related to perceived restorative outcomes and vitality in different green environments in field conditions and to show that urban-nature orientedness and noise sensitivity affect restoration differently in different environments. City planning should recognize different user needs by providing a varied urban environment where also green areas are widely accessible.

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Ethical issues

The field experiment was conducted according to the principles of the Declaration of Helsinki, adopted by the World Medical Association. A written explanation was provided for the participants, and written informed consent was obtained from all research subjects prior to conducting the experiment. The study was approved by the ethical committee of the hospital district of Northern Savo.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.healthplace.2018.11.004](https://doi.org/10.1016/j.healthplace.2018.11.004).

References

- Africa, J., Logan, A., Mitchell, R., Korpela, K., Allen, D., Tyrväinen, L., Nisbet, E., Li, Q., Tsunetsugu, Y., Miyazaki, Y., Spengler, J., on behalf of the NEI Working Group, 2014. The natural environments initiative: illustrative review and workshop statement. *Cent. Health Glob. Environ. Harv. Sch. Public Health*.
- Beil, K., Hanes, D., 2013. The influence of urban natural and built environments on physiological and psychological measures of stress: a pilot study. *Int. J. Environ. Res. Public Health* 10, 1250–1267. <https://doi.org/10.3390/ijerph1004125>.
- Benfield, J.A., Bell, P.A., Troup, L.J., Soderstrom, N., 2010. Does anthropogenic noise in national parks impair memory? *Environ. Behav.* 42 (5), 693–706.
- Björk, J., Albin, M., Grahn, P., Jacobsson, H., Ardö, J., Wadbro, J., Östergren, P.-O., Skärbäck, E., 2008. Recreational values of the natural environment in relation to neighbourhood satisfaction, physical activity, obesity and wellbeing. *J. Epidemiol. Community Health* 62 (4), e2.
- Bostic, T.J., Rubio, D.M., Hood, M.A., 2000. Validation of the Subjective Vitality Scale using structural equation modelling. *Soc. Indic. Res.* 52, 313–324.
- 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.
- Bratman, G., N., Daily, G.C., Levy, B.J., Gross, J.J., 2015. The benefits of nature experience: improved affect and cognition. *Landsc. Urban Plan.* 138 (6), 41–50. <https://doi.org/10.1016/j.landurbplan.2015.02.005>.
- City of Helsinki, 2015. Keskuspuisto management plan for the years 2016–2025, a draft. (Keskuspuiston luonnonhoidon yleissuunnitelma, suunnitelmaraportti – luonnon, 2016–2018). Available at: https://www.hel.fi/static/hkr/hoito_ja

- kehittamissuunnitelmat/keskuspuisto/Keskuspuiston_suunnitelmaraportti_luonnos.pdf> (29.06.2018), in Finnish.
- Collado, S., Staats, H., Sorrel, M.A., 2016. Helping out on the land: effects of children's role in agriculture on reported psychological restoration. *J. Environ. Psychol.* 45, 201–209.
- Eurostat, Statistics on European Cities, 2016. Available at: <http://ec.europa.eu/eurostat/statisticsexplained/index.php/Statistics_on_European_cities> (27.09.2016).
- Faehnle, M., Bäcklund, P., Tyrväinen, L., 2011. Looking for the role of nature experiences in planning and decision making: a perspective from the Helsinki Metropolitan area. *Sustain.: Sci. Pract. Policy* 7 (1), 45–55.
- Faehnle, M., Bäcklund, P., Tyrväinen, L., Niemelä, J., Yli-Pelkonen, V., 2014. How can residents' experiences inform planning of urban green infrastructure? Case Finland. *Landscape Urban Plan.* 130, 171–183.
- Gidlow, C.J., Jones, M.V., Hurst, G., Masterson, D., Clark-Carter, D., Tarvainen, M.P., Smith, G., Nieuwenhuijsen, M., 2016. Where to put your best foot forward: psychophysiological responses to walking in natural and urban environments. *J. Environ. Psychol.* 45 (3), 22–29. <https://doi.org/10.1016/j.jenvp.2015.11.003>.
- Hartig, T., 2004. Restorative environments. In: Spielberger, C. (Ed.), *Encyclopedia of Applied Psychology*. Academic Press, San Diego, pp. 272–279.
- Hartig, T., Lindblom, K., Ovefelt, K., 1998. The home and near-home area offer restoration opportunities differentiated by gender. *Scand. Hous. Plan. Res.* 15, 283–296.
- Hartig, T., Evans, G.W., Jamner, L.D., Davis, D.S., Gärling, T., 2003. Tracking restoration in natural and urban field settings. *J. Environ. Psychol.* 23, 109–123. [https://doi.org/10.1016/S0272-4944\(02\)00109-3](https://doi.org/10.1016/S0272-4944(02)00109-3).
- Hartig, T., Mitchell, R., de Vries, S., Frumkin, H., 2014. Nature and health. *Annu. Rev. Public Health* 35, 207–228.
- Hauru, K., Lehvävirta, S., Korpela, K., Kotze, D.J., 2012. Closure of view to the urban matrix has positive effects on perceived restorativeness in urban forests in Helsinki, Finland. *Landscape Urban Plan.* 107, 361–369.
- Heinonen-Guzejev, M., Vuorinen, H.S., Mussalo-Rauhamaa, H., Heikkilä, K., Kaprio, J., Koskenvuo, M., 2004. Somatic and psychological characteristics of noise-sensitive adults in Finland. *Arch. Environ. Health* 59 (8), 410–417.
- Heinonen-Guzejev, M., Vuorinen, H.S., Mussalo-Rauhamaa, H., Heikkilä, K., Koskenvuo, M., Kaprio, J., 2005. Genetic component of noise sensitivity. *Twin Res. Hum. Genet.* 8 (3), 245–249. <https://doi.org/10.1375/1832427054253112>.
- Heinonen-Guzejev, M., Vuorinen, H.D., Mussalo-Rauhamaa, H., Heikkilä, K., Koskenvuo, M., Kaprio, J., 2007. The association of noise sensitivity with coronary heart and cardiovascular mortality among Finnish adults. *Sci. Total Environ.* 372 (2–3), 406–412. <https://doi.org/10.1016/j.scitotenv.2006.08.048>.
- Hirvonen, J., 2000. Residential choices between two different profession groups. In: Ilmonen, M., Hirvonen, J., Knuuti, L., Korhonen, H., Lankinen, M., Lankinen, M. (Eds.), *Peace and Carnivals – Housing preferences of IT-professionals in Helsinki Metropolitan area*. Helsinki Polytechnic University (in Finnish) (Yhdyskuntasuunnittelun tutkimus- ja koulutuskeskuksen julkaisuja, B 78).
- Horiuchi, M., Endo, J., Akatsuka, S., Uno, T., Hasegawa, T., Seko, Y., 2013. Influence of forest walking on blood pressure, profile of mood States, and stress markers from the viewpoint of aging. *J. Aging Gerontol.* 1, 9–17. <https://doi.org/10.12974/2309-6128.2013.01.01.2>.
- Huang, J., Deng, F., Wu, S., Lu, H., Hao, Y., Guo, X., 2013. The impacts of short-term exposure to noise and traffic-related air pollution on heart rate variability in young healthy adults. *J. Expo. Sci. Environ. Epidemiol.* 23 (5), 559–564. <https://doi.org/10.1038/jes.2013.21>.
- Joyner, M.J., Wallin, B.G., Charkoudian, N., 2016. Sex differences and blood pressure regulation in humans. *Exp. Physiol.* 101, 349–355. <https://doi.org/10.1113/EP085146>.
- Kals, E., Schumacher, D., Montada, L., 1999. Emotional affinity toward nature as a motivational bases to protect nature. *Environ. Behav.* 31 (2), 178–202.
- Kaplan, R., Kaplan, S., 1989. *The Experience of Nature: A Psychological Perspective*. Cambridge University Press, Cambridge.
- Kaplan, S., 1995. The restorative benefits of nature: toward an integrated framework. *J. Environ. Psychol.* 15, 169–182.
- Korpela, K., Ylén, M., 2009. Effectiveness of favorite place prescriptions – a field experiment. *Am. J. Prev. Med.* 36, 435–438.
- Korpela, K., Ylén, M., Tyrväinen, L., Silvennoinen, H., 2008. Determinants of restorative experiences in everyday favourite places. *Health Place* 14, 636–652.
- Korpela, K., Ylén, M., Tyrväinen, L., Silvennoinen, H., 2010. Favorite green, waterside and urban environments, restorative experiences and perceived health in Finland. *Health Promot. Int.* 25 (2), 200–209. <https://doi.org/10.1093/heapro/daq007>.
- Korpela, K.M., Kinnunen, U., 2011. How is leisure time interacting with nature related to the need for recovery from work demands? Testing multiple mediators. *Leis. Sci.* 33, 1–14.
- Lafortezza, R., Carrus, G., Sanesi, G., Davies, C., 2009. Benefits and well-being perceived by people visiting green spaces in periods of heat stress. *Urban For. Urban Green.* 8, 97–108. <https://doi.org/10.1016/j.ufug.2009.02.003>.
- Lanki, T., Ahokas, A., Alm, S., Janssen, N.A.H., Hoek, G., De Hartog, J.J., Brunekreef, B., Pekkanen, J., 2007. Determinants of personal and indoor PM_{2.5} and absorbance among elderly subjects with coronary heart disease. *J. Expo. Sci. Environ. Epidemiol.* 17 (2), 124–133. <https://doi.org/10.1038/sj.jes.7500470>.
- Lanki, T., Sipilonen, T., Ojala, A., Korpela, K., Pennanen, A., Tiittanen, P., Tsunetsugu, Y., Kagawa, T., Tyrväinen, L., 2017. Acute effects of visits to urban green environments on cardiovascular physiology in women: a field experiment. *Environ. Res.* 159, 176–185. <https://doi.org/10.1016/j.envres.2017.07.039>.
- Laumann, K., Gärling, T., Stormark, K.M., 2003. Selective attention and heart rate responses to natural and urban environments. *J. Environ. Psychol.* 23 (2), 125–134.
- Lee, J., Tsunetsugu, Y., Takayama, N., Park, B.J., Li, Q., Song, C., Komatsu, M., Ikei, H., Tyrväinen, L., Kagawa, T., Miyazaki, Y., 2014. Influence of forest therapy on cardiovascular relaxation in young adults. *Evid.-Based Complement. Altern. Med.* 834360. <https://doi.org/10.1155/2014/834360>.
- 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. *J. Epidemiol. Community Health* 63 (12), 967–973. <https://doi.org/10.1136/jech.2008.079038>.
- Martens, D., Gutscher, H., Bauer, N., 2011. Walking in "wild" and "tended" urban forests: the impact on psychological well-being. *J. Environ. Psychol.* 31 (1), 36–44. <https://doi.org/10.1016/j.jenvp.2010.11.001>.
- Mayer, F.S., McPherson Frantz, C., 2004. The connectedness to nature scale: a measure of individual's feeling in community with nature. *J. Environ. Psychol.* 24, 503–515.
- Mayer, F.S., McPherson Frantz, C., Bruehlman-Sencal, E., Dolliver, K., 2009. Why is nature beneficial?: the role of connectedness to nature. *Environ. Behav.* 41, 607–643. <https://doi.org/10.1177/0013916508319745>.
- Mitchell, R., Popham, F., 2008. Effect of exposure to natural environment on health inequalities: an observational population study. *Lancet* 372 (9650), 1655–1660.
- Nikolic, S.B., Abhayaratna, W.P., Leano, R., Stowasser, M., Sharman, J.E., 2014. Waiting a few extra minutes before measuring blood pressure has potentially important clinical and research ramifications. *J. Hum. Hypertens.* 28 (1), 56–61. <https://doi.org/10.1038/jhh.2013.38>.
- Nisbet, E.K., Zelenski, J.M., 2011. Underestimating nearby nature: affective forecasting errors obscure the happy path to sustainability. *Psychol. Sci.* 22 (9), 1101–1106.
- Nisbet, E.K., Zelenski, J.M., Murphy, S.A., 2009. The Nature Relatedness Scale: linking individuals' connection with nature to environmental concern and behaviour. *Environ. Behav.* 41, 715–740.
- Nix, G.A., Ryan, R.M., Manly, J.B., Deci, E.L., 1999. Revitalization through self-regulation: the effects of autonomous and controlled motivation on happiness and vitality. *J. Exp. Soc. Psychol.* 35, 266–284.
- Nordh, H., Hartig, T., Hägerhall, C.M., Fly, G., 2009. Components of small urban parks that predict the possibility for restoration. *Urban For. Urban Green.* 8 (4), 225–235. <https://doi.org/10.1016/j.ufug.2009.06.003>.
- Okokon, E.O., Turunen, A.W., Ung-Lanki, S., Vartiainen, A.K., Tiittanen, P., Lanki, T., 2015. Road-traffic noise: annoyance, risk perception, and noise sensitivity in the Finnish adult population. *Int. J. Environ. Res. Public Health* 26, 5712–5734.
- Palmquist, E., Claeson, A.S., Neely, G., Stenberg, B., Nordin, S., 2014. Overlap in prevalence between various types of environmental intolerance. *Int. J. Hyg. Environ. Health* 217, 427–434.
- Park, B.J., Tsunetsugu, Y., Kasetani, T., Morikawa, T., Kagawa, T., Miyazaki, Y., 2009. Physiological effects of forest recreation in a young conifer forest in Hinokage town, Japan. *Silva Fenn.* 43, 291–301.
- Park, B.J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., Miyazaki, Y., 2010. The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan. *Environ. Health Prev. Med.* 15 (1), 18–26.
- 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? *Environ. Behav.* 7, 1–32. <https://doi.org/10.1177/0013916517720261>.
- Paunovic, K., Jakovljevic, B., Belojevic, G., 2009. Predictors of noise annoyance in noisy and quiet urban streets. *Sci. Total Environ.* 407, 3707–3711.
- Pietilä, M., Neuvonen, M., Borodulin, K., Korpela, K., Sievänen, T., Tyrväinen, L., 2015. Relationships between exposure to urban green spaces, physical activity and self-rated health. *J. Outdoor Recreat. Tour.* 10, 44–54.
- Pugh, T.A., Mackenzie, A.R., Whyatt, J.D., Hewitt, C.N., 2012. Effectiveness of green infrastructure for improvement of air quality in urban street canyons. *Environ. Sci. Technol.* 46 (14), 7692–7699. <https://doi.org/10.1021/es300826w>.
- Ryan, R.M., Frederick, C., 1997. On energy, personality, and health: subjective vitality as a dynamic reflection of well-being. *J. Personal.* 65 (3), 529–565.
- Ryan, R.M., Bernstein, J.H., Brown, K.W., 2010a. Weekends, work, and well-being: psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *J. Soc. Clin. Psychol.* 29, 95–122.
- Ryan, R.M., Weinstein, N., Bernstein, J., Brown, K.W., Mistretta, L., Gagné, M., 2010b. Vitalizing effects of being outdoors and in nature. *J. Environ. Psychol.* 30, 159–168.
- Selander, J., Bluhm, G., Theorell, T., Pershagen, G., Babisch, W., Seiffert, I., Houthuijs, D., Breugelmans, O., Vigna-Taglianti, F., Antonietti, M.C., Velonakis, E., Davou, E., Dudley, M.L., Järup, L., HYENA Consortium, 2009. Saliva cortisol and exposure to aircraft noise in six European countries (1731–1717). *Environ. Health Perspect.* 117 (11). <https://doi.org/10.1289/ehp.0900933>.
- Shepherd, D., Welch, D., Dirks, K.N., Mathews, R., 2010. Exploring the relationship between noise sensitivity, annoyance and health-related quality of life in a sample of adults exposed to environmental noise. *Int. J. Environ. Res. Public Health* 7 (10), 3579–3594. <https://doi.org/10.3390/ijerph7103580>.
- Singh-Manoux, A., Martikainen, P., Ferrie, J., Zins, M., Marmot, M., Goldberg, M., 2006. What does self-rated health measure? Results from the British Whitehall II and French Gazel cohort studies. *J. Epidemiol. Community Health* 60 (4), 364–372.
- Staats, H., Kieviet, A., Hartig, T., 2003. Where to recover from attentional fatigue: an expectancy-value analysis of environmental preference. *J. Environ. Psychol.* 23, 147–157.
- Stansfeld, S.A., 1992. Noise, noise sensitivity and psychiatric disorder: epidemiological and psychophysiological studies. *Psychol. Med. Suppl.* 22, 1–44.
- Tassi, P., Rohmer, O., Schimchowitscha, S., Eschenlauer, A., Bonnefond, A., Margiochic, F., Poisson, F., Muzet, A., 2010. Living alongside railway tracks: long-term effects of nocturnal noise on sleep and cardiovascular reactivity as a function of age. *Environ. Int.* 36 (7), 683–689. <https://doi.org/10.1016/j.envint.2010.05.001>.
- ten Brink, P., Mutafoğlu, K., Schweitzer, J.-P., Kettunen, M., Twigger-Ross, C., Baker, J., Kuipers, Y., Emonts, M., Tyrväinen, L., Hujala, T., Ojala, A., 2016. The health and social benefits of nature and biodiversity protection. A Report for the European

- Commission (ENV.B.3/ETU/2014/0039). Institute for European Environmental Policy, London/Brussels.
- ten Brummelhuis, L.L., Bakker, A.B., 2012. Staying engaged during the week: the effect of off-job activities on next day work engagement. *J. Occup. Health Psychol.* 17 (4), 445–455.
- Tsunetsugu, Y., Park, B.J., Ishii, H., Hirano, H., Kagawa, T., Miyazaki, Y., 2007. Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) in an old-growth broadleaf forest in Yamagata prefecture, Japan. *J. Physiol. Anthropol.* 26 (2), 135–142.
- Tsunetsugu, Y., Lee, Y., Park, B.J., Tyrväinen, L., Kagawa, T., Miyazaki, J., 2013. Physiological and psychological effects of viewing urban forest landscapes assessed by multiple measurements. *Landsc. Urban Plan.* 113 (5), 90–93.
- Tyrväinen, L., Miettinen, A., 2000. Property prices and urban forest amenities. *J. Environ. Econ. Manag.* 39 (2), 205–223.
- Tyrväinen, L., Silvennoinen, H., Kolehmainen, O., 2003. Ecological and aesthetic values in urban forest management. *Urban For. Urban Green.* 1 (3), 135–149.
- Tyrväinen, L., Pauleit, S., Seeland, K., de Vries, S., 2005. Benefits and uses of urban forests and trees. In: Nilsson, K., Randrup, T.B., Konijnendijk, C.C. (Eds.), *Urban Forests and Trees in Europe - A Reference Book*. Springer Verlag, pp. 81–114.
- 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. *J. Environ. Psychol.* 38 (6), 1–9. <https://doi.org/10.1016/j.jenvp.2013.12.005>.
- Tyrväinen, L., Mäkinen, K., Schipperijn, J., 2007a. Tools for mapping social values of urban woodlands and other green areas. *Landsc. Urban Plan.* 79 (1), 5–19.
- Tyrväinen, L., Silvennoinen, H., Korpela, K., Ylén, M., 2007b. Importance of nature and its effect on psychological well-being. In: Tyrväinen, L., Tuulentie, S. (Eds.), *Nature-based Tourism, Forests and Well-being*, Metla's working papers 52, ISBN 978-951-40-2045-2 (PDF), pp. 57–77.
- Ulrich, R., 1983. *Aesthetic and Affective Response to Natural Environment*. Behaviour and the Natural Environment. Springer, US, pp. 85–125.
- United Nation, World Urbanization Prospects, 2014. Available at: <https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf> (26.09.2016).
- Van den Berg, Jorgensen, A., Wilson, E., 2014. Evaluating difference in urban green spaces: does setting type make a difference? *Landsc. Urban Plan.* 127 (7), 173–181. <https://doi.org/10.1016/j.landurbplan.2014.04.012>.
- Van den Berg, A.E., Koole, S.L., Van der Wulp, N.Y., 2003. Environmental preference and restoration: (how) are they related? *J. Environ. Psychol.* 23 (2), 135–146. [https://doi.org/10.1016/S0272-4944\(02\)00111-1](https://doi.org/10.1016/S0272-4944(02)00111-1).
- Van Kempen, E., Babisch, W., 2012. The quantitative relationship between road traffic noise and hypertension: a meta-analysis. *J. Hypertens.* 30 (6), 1075–1086. <https://doi.org/10.1097/HJH.0b013e328352ac54>.
- Von Lindern, E., Bauer, N., Frick, J., Hunziker, M., Hartig, T., 2013. Occupational engagement as a constraint on restoration during leisure time in forest settings. *Landsc. Urban Plan.* 118, 90–97. <https://doi.org/10.1016/j.landurbplan.2013.03.001>.
- Von Lindern, E., Hartig, T., Lercher, P., 2016. Traffic-related exposures, constrained restoration, and health in the residential context. *Health Place* 39, 92–100. <https://doi.org/10.1016/j.healthplace.2015.12.003>.
- Von Lindern, E., Lymeus, F., Hartig, T., 2017. The restorative environment: a complementary concept for salutogenesis studies. In: Mittelmark, M.B. (Ed.), *The Handbook of Salutogenesis*. Springer, pp. 181–195.
- Weinstein, N.D., 1978. Individual differences in reactions to noise: a longitudinal study in a college dormitory. *J. Appl. Psychol.* 63, 458–466. <https://doi.org/10.1037/0021-9010.63.4.458>.