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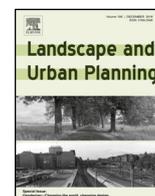
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Nature at home and at work: Naturally good? Links between window views, indoor plants, outdoor activities and employee well-being over one year



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HIGHLIGHTS

- We studied two-directional associations of nature exposure with employee well-being.
- Physical activity in nature during free time predicted vitality.
- Exposure to the natural world at work was not linked to the well-being measures.
- Conversely, affective well-being predicted the type of nature exposure.
- Physical activity in nature is a potential strategy for enhancing employee vitality.

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ABSTRACT

We investigated two-directional relations between various types of exposure to the natural world, at work and at home, and employee well-being. In total, 841 employees answered an electronic questionnaire twice with a one-year interval. Path analysis indicated that frequent physical activity in natural surroundings during free time predicted greater vitality over a one-year period after including control variables. The use of one's yard/garden and happiness were marginally positively associated over time. None of the variables involving exposure to the natural world at work were linked to the well-being measures. In the reverse direction, creativity at work predicted more frequent and vitality less frequent use of one's domestic garden. Happiness was marginally positively related to the frequency of physical activity in nature. The results suggest that free time physical activity in natural surroundings is a potential strategy for enhancing employee vitality across time.

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1. Introduction

Looking at the natural world from the window can be regarded as a “micro-restorative” experience that according to the Attention Restoration Theory (ART) can fence off frustration and boost enthusiasm about one's job thus promoting employee well-being (Kaplan, 1993), i.e., optimal psychological functioning and experience (Ryan & Deci, 2001). Being exposed at workplaces to window views over greenspace has been related to several well-being out-

comes like lower physiological arousal and anxiety (Chang & Chen, 2005) and better job satisfaction (Lottrup, Stigsdotter, Meilby, & Claudi, 2013) compared with built urban views.

The link between nature exposure and well-being is evident also in the psychophysiological stress recovery theory (SRT), another major theoretical perspective in environmental psychology (Ulrich et al., 1991; Bratman, Hamilton, & Daily, 2012). According to SRT, a visual encounter with natural scenes prompts an automatic shift towards more positive emotional states, increases parasympathetic activity inducing relaxation (Gladwell et al., 2012), and blocks negative emotions and thoughts.

Complementing the idea of the restorative effects of nature by ART and SRT, some studies have suggested that exposure to the natural world also has (re-)vitalizing effects (Ryan et al., 2010). Vitality includes positive feelings that are more energized than the feelings

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of restoration or relaxation (Ryan et al., 2010). Subjective vitality is a feeling of aliveness (Nix, Ryan, Manly, & Deci, 1999) and activated positive affect (Ryan et al., 2010). Vitality increases positive coping responses, better self-control and enhances productiveness (Ryan & Deci, 2008), all relevant to employee well-being. In the literature, the vitalizing effects of nature exposure have received less research attention than the stress-reducing aspects. Thus, in this study we investigate whether the perceptions of the use of natural elements at work and at home are related to positive and self-enhancing aspects of employee well-being, particularly subjective vitality. Moreover, a relevant outcome deserving investigation in this context is the feeling of creativity at work which may be related to vitality and result from attention restoration and lower stressful arousal after nature exposure (Atchley, Strayer, & Atchley, 2012).

In the following, we review studies on the associations of window views, plants, and physical activity in nature with well-being and work-related outcomes. We maintain that important gaps in research concern causal directions and the relative importance of different types of nature exposure. Our study aims to address these gaps by using a longitudinal design including several types of nature exposure.

1.1. Gaps in knowledge: the relative importance of the types of nature exposure and causal directions

Despite a large body of empirical results, the relative importance of different forms of exposure to the natural world for well-being remains elusive. Many studies have focused on nature exposure only within the workplace (Aries, Veitch, & Newsham, 2010; Largo-Wight, Chen, Dodd, & Weiler, 2011). In this study, we compare the perceptions of exposure to the natural world at the workplace with the perceptions of exposure to the natural world in residential and free time environments. To the best of our knowledge, only one study so far has taken into account the latter when studying the relationship between the use of greenspace at the workplace and well-being (Gilchrist, Brown, & Montarzino, 2015). The cross-sectional results of that study indicated that knowledge workers' use of greenspace near their workplaces and window views of nature were positively associated with self-reported well-being when controlling for the use of domestic garden and outdoor activity.

Other cross-sectional studies have demonstrated several well-being benefits but have not increased our understanding about the temporal and causal nature of the relationships. For example, existing survey studies have related *offices with plants* (versus lean offices) with greater overall job satisfaction, self-rated quality of life (Dravigne, Waliczek, Lineberger, & Zajicek, 2008), self-reported creativity, and work satisfaction (Bringslimark, Hartig, & Patil, 2007). Regarding *physical activity (PA) in natural surroundings*, a link to less need for recovery from work has been reported (Korpela & Kinnunen, 2011). Conversely, the higher the level of emotional demands at the job, the more often the outdoor recreation areas in the vicinity of home are visited on workdays (Degenhardt, Frick, Buchecker, & Gutscher, 2011).

Experimental research on nature exposure and well-being, in turn, has focused mainly on short-term effects (Knight & Haslam, 2010) and shown mixed results. For instance, one study found that working in “green offices” resulted in better performance in an attention capacity test (Raanaas, Evensen, Rich, Sjøstrøm, & Patil, 2011) whereas another study found no change in either directed attention capacity or self-reported restoration (Evensen, Raanaas, Hägerhäll, Johansson, & Patil, 2015). However, experiments with follow-ups have indicated that enriching a previously lean office with plants was associated with less disengagement (e.g., feelings of apathy or tiredness) among employees, which in turn enhanced their workplace satisfaction in the short-term

(2 weeks) and the long-term (3.5 months) (Nieuwenhuis, Knight, Postmes, & Haslam, 2014). Studies comparing nature walks with urban walks have shown positive short-term effects of nature walks on attention restoration and on nervous system arousal (Aspinall, Mavros, Coyne, & Roe, 2015; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010). Similarly, a study comparing different lunchtime walks in the workplace showed improvement in self-reported mental health only in the nature walk group (Brown, Barton, Pretty, & Gladwell, 2014). Exposure to nature in the form of gardening has shown short-term restorative effects on mood and cortisol when compared to indoor reading (van den Berg & Custers, 2011).

Some longitudinal intervention studies suggest a predictive role for nature exposure in well-being. For example, gardening as well as nature-based therapies have been related to better overall health and well-being among adults (Groenewegen, van den Berg, de Vries, & Verheij, 2006; Währborg, Petersson, & Grahn, 2014). Longitudinal studies with a focus on the general population have suggested that more greenspace in residential areas is related to lower levels of stress (Ward Thompson et al., 2012) and that moving to greener areas is related to greater subsequent happiness and life satisfaction (White, Alcock, Wheeler, & Depledge, 2013).

1.2. Research questions and hypotheses

The present study addresses several gaps in the research by exploring relationships between self-reported exposure to the natural world both at work and at home and employees' experiences of well-being. We study the positive and self-enhancing aspects of well-being: vitality, happiness, vigor, and creativity. These relationships are examined over time (one year) as longitudinal evidence comparing different types of nature exposure is scarce. Furthermore, we aim to investigate exposure to the natural world in a wider context than previously by controlling for theoretically relevant job characteristics and the stability of well-being experiences over time.

To contribute to the rare comparisons between different types of exposure to the natural world, we selected perceived nature exposure variables that reflect different environments – natural elements at work (the number of indoor plants, views from windows, looking out of the window), at home (looking out of the window, being in the garden), and during free time (physical activities in natural surroundings). The only study so far controlling for the presence of a domestic garden and participation in outdoor activities (Gilchrist et al., 2015) did not control for the frequency of looking out of windows or the use of the domestic garden. Moreover, our nature exposure variables represent a perceived dimension of increasing immersion in natural surroundings and an increasing amount of physical activity (from sitting and looking at plants to outdoor recreation). This concurs with some indications in the literature of a linear dose-response relationship between exposure to the natural world and well-being outcomes (Fjeld, 2000; Jiang, Li, Larsen & Sullivan, 2014).

As the majority of earlier studies are cross-sectional causality has remained largely an open question. In our study, we aim to generate better conditions for causal hypotheses by using a two-wave panel design. We use a one-year time-lag as previous studies provide a range from one year (Astell-Burt, Mitchell, & Hartig, 2014; Kinnunen & Feldt, 2013; White et al., 2013) to five years for potential long-term effects. In a 5-year follow-up study, green qualities around the residence in an interaction with physical activity predicted mental health (e.g., happiness, ability to face problems and enjoy everyday activities) for women (Annerstedt et al., 2012). To understand these previous results and justify the one-year lag, we speculate that the types of nature exposure in our study (e.g., looking out, being physically active) represent ongoing daily, weekly,

or monthly recurrent loops of behaviors that, in principle, can affect well-being over longer time periods, such as one year. Thus, encountering nature exposures day after day will increase the likelihood of continuously high well-being.

Our well-being variables are consistent with research on vitality, attention and stress restoration but reflect the positive and self-enhancing rather than stress-reducing aspects of well-being. We include experiences of *vitality* and *happiness*, which have been differentiated because vitality is characterized by high energy or activation, which is not necessarily true of happiness (Nix et al., 1999). Vitality-related affects are, for example, peppy, active, and enthusiastic, whereas happiness-related affects may be content and satisfied (Nix et al., 1999). We also consider *vigor at work* as a job-related well-being experience of vitality. Vigor is a key dimension of work engagement and refers to high levels of energy and mental resilience while working, the willingness to invest in one's work, and perseverance in the face of difficulties (Schaufeli, Salanova, González-Romá, & Bakker, 2002). Further, *creativity at work*, defined as the production of novel, useful ideas or problem solutions (Amabile, Barsade, Mueller, & Staw, 2005) may result from attention restoration and lower stressful arousal in nature (Atchley et al., 2012). The effects of nature on positive mood (e.g., happiness) and the consequent stimulation for insight and divergent associations have also been proposed as mechanisms increasing performance in creative tasks (Shibata & Suzuki, 2002, 2004).

Based on previous cross-sectional findings we anticipate that (H1) different perceived types and degrees of nature exposure are all positively and independently (after accounting for other variables) related to well-being outcomes over one year. An interesting question is whether happiness, vitality, vigor, and creativity are interrelated psychological processes and show consistent associations with nature exposure or whether benefits differ with different well-being outcomes.

In addition, we include adequate control variables that represent alternative explanations for the relationships between nature exposure and well-being. In the employee well-being literature, vitality, energy, and self-regulatory capacities – reflected in our outcomes of vitality, happiness, vigor, and creativity – are assumed to be enhanced by satisfaction of needs for relatedness (feeling connected), autonomy (sense of choice), and competence (effectiveness) (Ryan & Deci, 2001, 2008). Consequently, job characteristics including 1) support from colleagues and superiors (relatedness), 2) autonomy at work (autonomy), and 3) workload (indicating a challenge and potential for competence) match these needs and are also the most important job characteristics affecting employee well-being in Karasek's well-known demand-control-support model (Karasek & Theorell, 1990). Thus, we control for them. Another alternative explanation not controlled for in previous studies is the number of breaks from work that a person takes during the day. More breaks have been related to better well-being and less fatigue (Tucker, 2003), which means more vigor and positive affective states. Hence, the number of breaks may be directly linked to well-being, and breaks may also provide more opportunities to engage with natural elements.

Furthermore, it is known that positive affects are moderately stable over months, even over years (Lucas & Donnellan, 2007; Watson & Walker, 1996). We account for this temporal stability which leaves explanatory power and variance only for important determinants and makes our study design a more stringent test for other explanatory variables. We also control for age and gender which may be associated with the dependent variables (Shibata & Suzuki, 2004).

Our last aim is to investigate both directions of the relationship between exposure to the natural world and well-being. There is compelling evidence that nature exposure improves well-being,

but as longitudinal studies are still few and experimental evidence is limited, the reverse or reciprocal directions of the relationships remain plausible. The reverse assumption states that better well-being increases exposure to nature (H2), whereas the reciprocal assumption views this relationship as bidirectional (H3). In support for the reversed effects, it is well known that mood affects an individual's selection of certain places, activities and experiences while there, and decisions to leave (Kerr & Tacon, 1999). In fact, the notion that people use particular places for self- and emotion regulation is a common presupposition in research on favorite places and restorative environments (Korpela, Hartig, Kaiser, & Fuhrer, 2001). The niche-building theory, based on a broader perspective of the person–environment fit (Roberts & Robins, 2004), posits that people tend to create, seek out, or end up in physical and social environments that correlate with their personal needs, dispositions, and abilities (Tesser, 2002). In travel and tourism studies, the desire of relaxation and restoration, and the preference for natural environments has been recognized as one basis of the choice of travel destinations (Lehto, 2013). From leisure studies, it is known that leisure involvement that includes physical activity follows from several intrinsic motives, such as identity affirmation, enjoyment, or physical fitness (Aaltonen et al., 2012). Hence, a multitude of perspectives and empirical results supports the notion of the active choice of environments to regulate one's well-being, potentially producing reverse effects.

2. Method

2.1. Sample and procedure

The participants were employees working in eleven organizations in different sectors, the largest of which were education, information technology, and media. By sampling different organizations, we wanted to include employees from a variety of different jobs. The organizations were mainly recruited from the client organizations of a company supplying occupational health care services. As not all types of natural environments may be restorative – for instance, dense wooded areas may also evoke fear and stress (Gatersleben & Andrews, 2013) – in the present study, we recruited workplaces near urban parks or woodlands (max. 150 m distance) that were well maintained and did not include threatening features.

The questionnaire data were collected in two waves as a part of a larger project on recovery at work aiming ultimately to a 3-wave design. In the first phase, in spring 2013 (Time 1) an electronic questionnaire was sent either directly to the employees' work e-mail addresses (in seven organizations) or the link to the questionnaire was delivered by the contact persons to the employees (in four organizations). Of the employees contacted ($N=3593$), 1347 returned the completed questionnaire after two reminders, yielding a response rate of 37.5%. Second, in spring 2014 (Time 2) another electronic questionnaire was sent to those employees who responded in 2013 and who were still employed in the same organizations ($N=1192$). Of these, a total of 841 employees returned the completed questionnaire, yielding a response rate of 70.6%. In both study phases, the employees received information about the goals of the study (“a longitudinal study about recovery from work including questionnaire with the themes of work, work environment, free-time, well-being, and health”) with the assurance that responses would be treated confidentially and that participation was voluntary. All the variables used in this study were measured at both time points T1 and T2.

At Time 1 of this longitudinal sample ($N=841$), 58.6% of participants were women. The participants' average age was 47.1 years (range 21–67, $SD=10.0$). Most of them (76.4%) were living with a partner (either married or cohabiting), and 45.6% had children

(average of two) living at home. Of the sample, 38.2% held a university degree (master's level or higher), 26.6% had a polytechnic degree, and the rest (35.2%) had a vocational school qualification or less. Of the participants, 8.3% were blue-collar workers (e.g., cleaners), 30.0% were lower-white collar workers (e.g., office workers), 57.8% were higher white-collar workers (e.g., teachers), and 3.8% were higher-level managers (e.g., chief executive officers). The majority had a permanent job (89.0%), worked full-time (96.8%), and had a regular day shift (89.7%). Average hours worked weekly were 39.1 ($SD=5.9$). Of the participants, 55.6% worked in the public sector, and the rest (39.4%) worked in the private sector.

In analyzing sample attrition we compared the respondents of the longitudinal sample (i.e., those who replied at T1 and T2) with the non-respondents (who did not reply at T2). The respondents did not differ from the non-respondents in terms of gender, age, having a partner, number of children, or education. The respondents were more often employed as higher white-collar workers (58% vs. 50%) than the non-respondents ($p<0.05$) and had more often a permanent employment contract (89% vs. 79%) than the non-respondents ($p<0.001$). Also, the respondents worked longer hours per week (39.1 vs. 37.9 h, $p<0.01$) and more often had a regular day shift (90% vs. 83%, $p<0.01$) than the non-respondents. When comparing the study variables at T1 (nature exposure, job characteristics, outcomes) two differences were found. The non-respondents at T2 reported having somewhat less autonomy at work ($M=3.1$, $SD=0.85$) than the long-term sample ($M=3.2$, $SD=0.82$; $t_{(1226)}=2.2$, $p=0.025$) and having slightly less social support ($M=3.9$, $SD=0.74$) than the long-term sample ($M=4.0$, $SD=0.66$; $t_{(672.3)}=2.0$, $p=0.043$).

2.2. Measures

In order to elevate the response rate, to cover several research themes and not to burden the employees excessively, we had to measure the variables as concise as possible in our questionnaire. In addition to perceived nature exposure and well-being, the questionnaire included several measures about the work situation, recovery and free time, not reported here.

2.2.1. Nature exposure variables at the workplace

The number of indoor plants was measured by one item asking "How many (artificial or real) plants or flowers do you have in sight inside your room/work station?". The response was given in numbers. We included artificial plants in light of the fact that even posters of plants can have similar although weaker effects on well-being than real plants (Beukeboom, Langeveld, & Tanja-Dijkstra, 2012).

The type of view from the window was measured by asking "Do you have a window, a glass door or a glass wall in your room/work station?". The response categories were 1) No, 2) Yes, it is to the inside of the building, 3) Yes, it is to the outside of the building with mainly an urban view (for example a building or street) 4) Yes, it is to the outside of the building with mainly a natural view (for example a lake, field, or park). For the statistical analyses, we used a dichotomous variable (1=indoor or urban view and 2=nature view) and excluded those with no views (5.9% of the sample).

Frequency of looking out of the window was measured in the context of energy management behaviors during the working day (De Bloom, Kinnunen, & Korpela, 2015). We recognized the difficulty of reporting on looking at plants or window view *per se* during the working day but thought that people might more easily recognize the moments when they felt elevated after looking at their surroundings. Thus, we asked "To what extent do you use each of the behaviors to manage your energy during your work day?" Among a list of 13 behaviors we included "Look out the window".

The response scale was a Likert scale from 1 "Very seldom or never" to 5 "Very often or always".

2.2.2. Nature exposure variables at home and during free time

Frequency of looking out at a nature view at home was measured with a question "Do you have a window or balcony view of natural surroundings, e.g., greenspace, water, or a garden?" with four response categories 0) No, 1) Yes, but I look at it fairly seldom, 2) Yes, and I look at it sometimes, 3) Yes, and I look at it often.

Use of one's own back yard (at home) with natural elements was measured with one item "Do you have a garden, yard, balcony or patio with natural (e.g., plants, flowers, trees) or water elements (e.g., a fountain, a pond)?" The response categories were 0) No, 1) Yes, but I use it seldom, 2) Yes, and I use it sometimes, 3) Yes, and I use it often.

Frequency of physical activities in natural surroundings during free time was measured with one item "How often do you spend free time on the following activities? Physical activities in natural surroundings (e.g., swimming, running, cycling)" was included in the list of seven activities. The response categories were 1) Hardly ever or a few times per year, 2) About once per month, 3) A few times per month, 4) About once per week, 5) A few times per week, 6) Almost every day.

2.2.3. Well-being variables

Happiness was measured with a single item ("How happy do you feel in general?") using a 10-point scale ranging from 1 (very unhappy) to 10 (very happy) (Abdel-Khalek, 2006; De Bloom, Geurts, & Kompier, 2013).

Vitality was measured with four items (excluding the synonymous expressions of energy) from the seven-item Subjective Vitality Scale (Ryan & Frederick, 1997) (e.g., "During the last month, I have felt alive and vital", Cronbach's alpha = 0.88_{T1} and 0.88_{T2}). The items were rated on a 5-point scale from 1 (very seldom or never) to 5 (very often or always).

Vigor at work was measured with three items (e.g., "At my work, I feel bursting with energy", Cronbach's alpha = 0.89_{T1} and 0.90_{T2}) from the shortened Utrecht Work Engagement Scale (UWES, Schaufeli, Bakker, & Salanova, 2006), of which the construct validity has been found to be good in Finnish occupational samples (Seppälä et al., 2009). The response scale ranged from 0 (never) to 6 (every day).

Creativity at work was measured with three items (e.g., "My head is full of innovative ideas that are related to my work", Cronbach's alpha = 0.84_{T1} and 0.86_{T2}) (George & Zhou, 2001; Jaussi, Randel, & Dionne, 2007) rated on a scale from 1 (very seldom or never) to 5 (very often or always).

2.2.4. Control variables

Job autonomy was measured with five items (e.g., "I can influence the amount of work assigned to me", Cronbach's alpha = 0.77_{T1} and 0.78_{T2}) rated on a 5-point scale from 1 (very seldom or never) to 5 (very often or always) from the QPS Nordic-ADW (Dallner et al., 2000).

Social support from colleagues was measured with three items (e.g., "If needed, I can get support and help with my work from my co-workers") and from supervisors with three items (e.g., "My work achievements are appreciated by my immediate superior") that were taken from the QPS Nordic-ADW (Dallner et al., 2000). Cronbach's alpha for support with colleagues and supervisors was 0.80_{T1} and 0.82_{T2}. The items were rated on a 5-point scale from 1 (very seldom or never) to 5 (very often or always).

Workload was measured with three items (e.g., "How often does your job require you to work under time pressure?"; Cronbach's alpha = 0.88_{T1} and 0.87_{T2}) from the QWI (Spector & Jex, 1998). The

items were rated on a scale from 1 (very seldom or never) to 5 (very often or always).

Number of breaks lasting over 10 min during a regular working day was elicited with an open-ended question. The response was given in numbers.

We also controlled for gender and age.

2.2.5. Statistical analyses

MANOVA and paired sample *t*-tests with SPSS 22.0 were used to examine the change in the mean level of the variables from T1 to T2 and zero-order correlations were calculated to examine the relationships between the study variables. We used a two-wave autoregressive cross-lagged panel model, the “traditional longitudinal model” (Selig & Little, 2012) to examine the hypothesized relationships across time. All variables were measured at T1 and T2. In the model, autoregressions reveal the stability or change of individuals’ relative standings on the construct from one occasion to the next (Selig & Little, 2012). Cross-lagged associations are relationships between “independent and dependent” variables, i.e., the effect of a construct on another measured at a later occasion. Cross-lagged effects are estimated controlling for autoregressions, that is, the prior level of the construct being predicted. The inclusion of autoregressions rules out the possibility that cross-lagged associations are due to the variables being correlated at T1 (Selig & Little, 2012). We ran this “normal causation” model in Mplus 7 including autoregressions of all variables and the cross-lagged regressions from nature exposure and control variables at T1 to four well-being measures at T2 (Fig. 1). We also ran the “reverse causation” model with happiness, vitality, vigor, and the sense of creativity at T1 predicting nature exposure and control variables at T2 to assess the direction of the hypothesized associations. Last, we ran the “reciprocal” model which assumes that these paths between variables were bidirectional.

Acceptable model fits were assessed with the following criteria: the χ^2 test (Bollen, 1989), Comparative Fit Index (CFI) and Tucker Lewis Index (TLI) with values greater than 0.90 or .95, Root Mean Square Error of Approximation (RMSEA) with values smaller than 0.06 – 0.08, and Standardized Root Mean Square Residual (SRMR) with values smaller than 0.08 (Schreiber, Nora, Stage, Barlow, & King, 2006). For the comparisons of non-nested models (normal vs. reversed), Akaike information criterion (AIC), Bayes information criterion (BIC) and sample-size adjusted BIC were used with the criterion “the smaller, the better” (Schreiber et al., 2006). For the comparison of nested models (reciprocal vs. normal or reversed), we used the Satorra-Bentler scaled χ^2 difference test. The models were estimated with the MLMV estimator, which is a maximum likelihood –based estimator that is robust to non-normality of observed variables (Muthén & Muthén, 1998–2012).

3. Results

3.1. Descriptive results

The correlations between the nature exposure variables were low (except for nature view at home and use of garden, balcony, or yard at home), indicating low multicollinearity (Table 1). The correlations between the nature exposure variables and control variables were likewise low. As anticipated, all nature exposure variables had some significant positive correlations with the well-being variables both cross-sectionally and over time.

The correlations between job-related control variables (autonomy, support, workload, breaks) and well-being variables were of moderate strength and mostly significant cross-sectionally and over time. The strongest cross-sectional correlations were between support and vitality, vigor and happiness. Workload correlated with

creativity but not with vigor, happiness, or vitality. Number of breaks correlated with happiness and vitality but not with vigor and creativity. Vigor, happiness, and vitality were interrelated quite strongly and significantly, creativity having lower but still significant relations to other well-being variables.

MANOVA revealed statistically significant ($Pillai F_{(13,671)} = 8.7$, $p < 0.001$) increases from T1 to T2 in the mean level (Table 1) of frequency of looking out of the window at work and at home, and number of breaks. Vigor, creativity, and workload decreased. As high correlations between dependent variables in MANOVA may reduce power, we confirmed these results with separate paired samples *t*-tests.

3.2. Autoregressive cross-lagged path models

Our hypothesized model of “normal causation” showed a good fit to the data except for the χ^2 test, which is generally known to be oversensitive with large samples (Bollen, 1989) ($\chi^2_{162} = 415.3$, $p < 0.001$; CFI = 0.95, TLI = 0.91; RMSEA = 0.05; SRMR = 0.04; AIC = 17.819; BIC = 18.609; adj BIC = 18.035). The model explained 43.9% of the variation in happiness, 40.1% in vitality, 46.3% in vigor, and 53.8% in sense of creativity at T2. Examination of the standardized coefficients (Table 2) showed that frequent physical activity in natural surroundings at T1 was associated with stronger feelings of vitality at T2. Frequency of using one’s back yard with nature elements at T1 was marginally related to happiness at T2. Of the control variables, workload and autonomy at T1 predicted higher creativity at work at T2 and support predicted vitality. Autoregression coefficients were substantial for happiness ($\beta = 0.63$), vitality ($\beta = 0.54$), vigor ($\beta = 0.64$), and creativity ($\beta = 0.70$), all $p < 0.001$, suggesting notable stability. All other coefficients were non-significant.

The “reverse causation model” had a nearly identical fit with the data ($\chi^2_{162} = 420.5$, $p < 0.001$; CFI = 0.95, TLI = 0.90; RMSEA = 0.05; SRMR = 0.04; AIC = 17.820; BIC = 18.611; adj BIC = 18.036) although the information criteria were slightly better in the “normal causation model”. The reversed model explained 53.6% of variance in number of plants, 34.7% in type of view from the window, 33.9% in frequency of looking out of the window at work, 26.8% in frequency of looking out of the window at home, 39.9% in use of garden, balcony, patio or yard with nature elements at home and 44.6% in frequency of physical activity in natural surroundings at T2. Standardized coefficients (Table 3) showed that sense of creativity at work at T1 predicted more frequent use of one’s back yard with nature elements at T2. Conversely, vitality at T1 predicted less frequent use of one’s back yard with nature elements at T2. Happiness was marginally positively related to the frequency of physical activity in nature. Autoregression coefficients were substantial; for indoor plants $\beta = 0.73$, for type of view from window $\beta = 0.59$, for frequency of looking out $\beta = 0.57$, for looking out at nature at home $\beta = 0.51$, use of yard/garden at home $\beta = 0.61$ and for physical activity in nature $\beta = 0.66$, all $p < 0.001$. All other coefficients were non-significant.

The “reciprocal model” showed no improvement in the model fit relative to the hypothesized normal ($\chi^2_{diff(40)} = 42.1$, $p = 0.38$) or reverse model ($\chi^2_{diff(40)} = 46.8$, $p = 0.21$). Furthermore, the reciprocal model revealed no new significant paths.

4. Discussion

Overall, we obtained limited support for the link between perceived nature exposure and employee well-being over time. The link between nature and well-being was not clearly unidirectional over time. While acknowledging the limitations in our design and measures, these “conservative” findings show that in real-life con-

Table 1
Means, standard deviations and Pearson correlations between nature elements at work and home, background, job characteristic and well-being variables.

	1	2	3	4	5	6	7 Gender ^a	8	12	13	14	15	16	17	18	19
	Plants	View type	Look out	View, home	Yard, home	Nature, PA	1 female 2 male	Age ^a	Breaks	Auto-nomy	Sup-port	Work load	Creativity T1 T2	Vigor T1 T2	Happiness T1 T2	Vitality T1 T2
1. Plants	<u>.69***</u>	-.05	.01	.04	.08*	.00	-.18***	-.01	-.12**	-.07*	.04	.19***	-.00	.08*	.00	-.04
2. View, urban vs nature	-.07	<u>.58***</u>	.08*	.03	.03	.02	.02	-.03	.00	.07	.04	-.03	.03	.05	.06	.09**
3. Looking out of the window	-.004	.12**	<u>.55***</u>	.16***	.09**	.12***	-.10**	-.01	.09**	.09**	.09**	.00	.10**	.09**	.04	.07
4. Nature view, home	.03	.004	.21***	<u>.57***</u>	.52***	.13***	-.05	.24***	.04	.04	.02	.04	.15***	.15***	.12***	.12***
5. Use of home garden / yard	.03	.02	.17***	.51***	<u>.66***</u>	.16***	-.04	.23***	.06	-.03	.02	.11***	.14***	.12***	.13***	.12***
6. Nature, phys.activity	.06	.05	.10**	.14***	.20***	<u>.66***</u>	-.18***	.00	.02	.01	.03	.02	.05	.08*	.14***	.16***
7. Gender ^a	-.22***	-.01	-.14***	-.08*	-.05	-.17***		.04	.23***	.16***	-.02	-.15***	.07*	-.09**	-.08*	.03
8. Age ^a	.001	-.03	.01	.25***	.28***	.03	.04		.16***	-.06	-.05	-.07	-.01	.00	-.02	.04
12. Freq of > 10 min. breaks	-.10**	.02	.11**	.04	.004	.07*	.26***	.07	<u>.67***</u>	.06	.05	-.22***	.03	.01	.09**	.09**
13. Autonomy	-.05	.003	.04	-.03	-.03	.03	.16***	-.08*	.07*	<u>.74***</u>	.34***	-.24***	.20***	.26***	.12***	.29***
14. Support	.11**	.05	.01	.00	.02	.05	-.02	-.10**	.02	.32***	<u>.63***</u>	-.05	.17***	.39***	.32***	.39***
15. Workload	.10**	-.09*	-.01	.05	.11**	.02	-.16***	.03	-.24***	-.30***	-.08*	<u>.69***</u>	.18***	.06	-.03	-.07*
16. CreativityT1	-.02	.08*	.08*	.11***	.12***	.04	.05	.01	-.01	.15***	.15***	.15***				
CreativityT2	.00	.05	.06	.09**	.08*	.05	.07*	-.01	-.01	.16***	.12***	.15***	<u>.72***</u>	.30***	.11**	.27***
17. Vigor T1	.09*	.07	.04	.10**	.12***	.19***	-.06	.01	.04	.26***	.39***	.01	.35***			
Vigor T2	.07*	.03	.05	.09*	.11***	.15***	-.09**	.00	.00	.19***	.29***	.04	.24***	<u>.68***</u>	.34***	.56***
													.33***			
18. HappinessT1	.05	.03	.03	.14***	.16***	.17***	-.12***	.004	.08*	.13***	.26***	.01	.14***	.41***		
Happiness T2	.04	.05	.03	.10**	.14***	.16***	-.08*	-.02	.10**	.11***	.24***	-.02	.15***	.37***	<u>.68***</u>	.50***
													.16***	.37***		
19. Vitality T1	.04	.06	.07	.11***	.12***	.20***	-.01	.002	.11**	.27***	.40***	-.07	.29***	.65***	.59***	
Vitality T2	.00	.07	.05	.11***	.12***	.19***	.03	.04	.11**	.22***	.30***	-.05	.26***	.50***	.47***	<u>.67***</u>
													.30***	.63***	.57***	
Response scale	0-20	1-2	1-5	0-3	0-3	1-6	1-2	21-67	0-8	1-5	1-5	1-5	1-5	0-6	1-10	1-5
Mean T1	2.28	20%	3.02	2.40	2.29	4.30	59%	47.13	2.44	3.18	3.99	3.89	3.45	4.53	7.77	3.37
(T2)	(2.12)	nature	(3.30)	(2.57)	(2.32)	(4.30)	female		(2.54)	(3.20)	(3.96)	(3.82)	(3.37)	(4.37)	(7.83)	(3.41)
SD T1	3.50	22%	1.20	.88	.96	1.30		10.02	1.12	.82	.66	.82	.77	1.21	1.59	.79
(T2)	(3.51)	nature	(1.13)	(.77)	(.90)	(1.30)			(1.18)	(.80)	(.69)	(.79)	(.77)	(1.32)	(1.52)	(.78)

*, **, *** Significant at $p \leq 0.05$, 0.01, or 0.001 respectively. $N = 683-841$. Upper triangle (grey area): intercorrelations at T2. Lower triangle: intercorrelations at T1 except well-being variables at T2. Autocorrelations between T1 and T2 on the diagonal, underlined. a: Gender and age are from T1—the same respondents answered at T2.

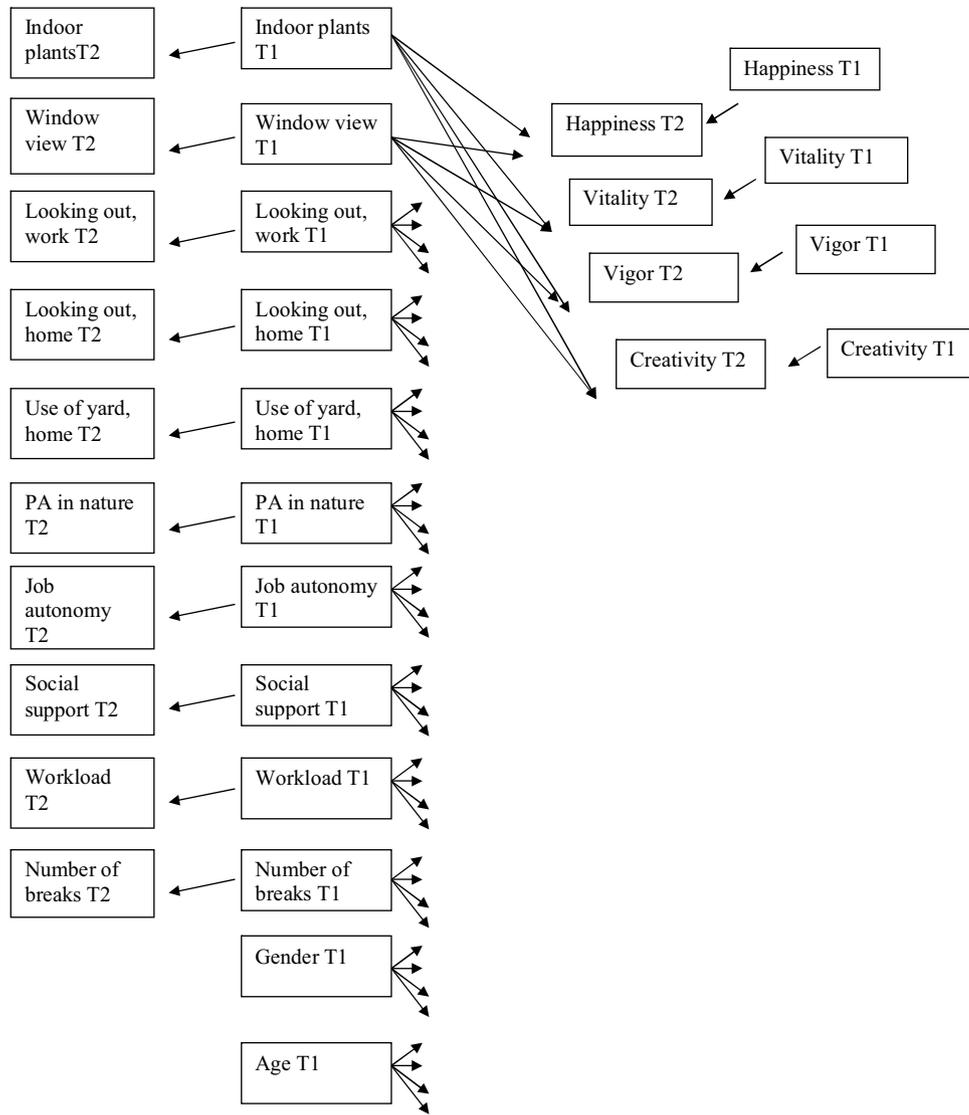


Fig. 1. The hypothetical “normal causation” two-wave autoregressive cross-lagged panel model. To simplify the figure, the four short arrows from each of the nature exposure and control variables represent paths to four well-being variables (happiness, vitality, vigor, creativity).

Table 2
 “Normal causation” model, standardized path coefficients between nature exposure, control and well-being variables in an autoregressive cross-lagged panel model. Significant coefficients are bolded, marginally significant ($p \leq 0.06$) in italics.

T2:	Happiness			Vitality			Vigor			Creativity		
	β	S.E.	p	β	S.E.	p	β	S.E.	p	β	S.E.	p
T1: 1. Plants	0.005	0.029	0.849	-0.006	0.027	0.837	0.024	0.028	0.384	0.010	0.025	0.689
2. View, urban vs. nature	0.031	0.028	0.283	0.028	0.031	0.365	0.004	0.029	0.897	-0.008	0.027	0.780
3. Looking out of the window	-0.005	0.030	0.870	-0.003	0.031	0.920	0.022	0.029	0.435	0.000	0.030	0.998
4. Nature view, home	-0.017	0.038	0.658	0.050	0.031	0.110	-0.017	0.031	0.574	0.006	0.032	0.853
5. Use of home garden/yard	<i>0.076</i>	<i>0.041</i>	<i>0.061</i>	0.032	0.035	0.362	0.051	0.032	0.107	-0.032	0.035	0.359
6. Nature, physical activity	0.036	0.037	0.321	0.070	0.033	0.031	0.005	0.029	0.855	0.013	0.029	0.648
7. Gender	-0.009	0.035	0.794	0.042	0.033	0.205	-0.053	0.030	0.072	0.039	0.031	0.206
8. Age	-0.046	0.034	0.177	0.045	0.032	0.157	-0.015	0.030	0.623	0.001	0.031	0.982
12. Freq of > 10 min breaks	0.001	0.036	0.982	0.051	0.034	0.135	0.013	0.030	0.650	-0.016	0.031	0.607
13. Autonomy	-0.004	0.039	0.912	0.049	0.036	0.173	0.024	0.031	0.447	0.086	0.032	0.008
14. Support	0.023	0.038	0.552	0.088	0.035	0.012	0.046	0.034	0.174	-0.005	0.030	0.875
15. Workload	0.014	0.037	0.694	0.024	0.032	0.455	0.010	0.031	0.745	0.078	0.029	0.008

texts only a small portion of the variance in employee well-being might be explained with perceived nature exposure after controlling for the stability of well-being and job characteristics. Our results highlight that the inclusion of physical activity in the interaction with nature might be more effective than more passive forms

of interaction. More specifically, the present results suggest that to promote employee vitality and happiness independently of job characteristics, age or gender, it may be beneficial to specifically stimulate and plan for nature-based free-time activities.

Table 3

“Reverse causation” model, standardized coefficients between well-being and nature exposure variables in an autoregressive cross-lagged panel model. Significant coefficients are bolded, marginally significant ($p \leq 0.06$) in italics. For brevity path coefficients to control variables are not reported.

T2: T1:	Plants	View, urban vs. nature	Looking out of the window	Nature view, home	Use of home garden/yard	Nature, physical activity
Happiness						
β	-0.008	0.030	0.047	-0.011	0.090	<i>0.073</i>
S.E.	0.036	0.038	0.040	0.059	0.049	<i>0.038</i>
<i>p</i>	0.829	0.427	0.237	0.858	0.067	<i>0.057</i>
Vitality						
β	-0.026	-0.051	-0.042	-0.013	-0.130	-0.004
S.E.	0.037	0.052	0.051	0.052	0.054	0.046
<i>p</i>	0.481	0.330	0.403	0.804	0.016	0.928
Vigor						
β	-0.010	-0.013	0.042	0.066	0.006	-0.015
S.E.	0.048	0.046	0.043	0.047	0.045	0.044
<i>p</i>	0.832	0.780	0.328	0.158	0.895	0.732
Creativity						
β	0.025	-0.002	0.060	0.024	0.082	0.022
S.E.	0.029	0.036	0.038	0.036	0.034	0.034
<i>p</i>	0.396	0.964	0.114	0.512	0.016	0.516

4.1. Hypothesis regarding exposure to the natural world, “normal causation model”

On the basis of previous findings, we anticipated that (H1) the perceptions of different types and degrees of exposure to the natural world would be positively and independently related to psychological well-being across time. Accordingly, more frequent, self-reported physical activity in nature predicted stronger feelings of vitality one year later. Hence, physical activities in nature revealed independent power in “explaining” vitality. However, the size of this association remained relatively small, possibly because we placed exposure to the natural world in a stringent test by including important job characteristics and the stability of well-being in our model. Autoregressions remained the most powerful determinants in the longitudinal models. Thus, vitality or happiness are quite stable interindividually across one year which constrains the size of the association that nature exposure can have with such feelings longitudinally.

Moreover, the more frequent use of one’s garden, back yard or patio was related to increased happiness but only marginally. Thus only the most intensive forms of exposure to the natural world – self-reported physical activity (to vitality) and the use of the garden (to happiness) – showed relations to some aspects of well-being over one year. Both exposures were related to home and free time environments.

Even though the mean levels of self-reported frequencies of looking out of the window at work and at home increased from the first measurement point to the second and the rest remained quite stable, none of the nature exposure variables at work predicted well-being. We speculated that nature exposure variables represent continually repeated behaviors over the year but were not able to check this empirically. On the other hand, if our non-significant results hold true also in future longitudinal studies, earlier cross-sectional survey results showing several positive effects of workplace nature exposure may have actually revealed only short-term associations and/or may have suffered from the common method variance bias. The existence and the form of a long-term dose-response relationship between nature exposure and well-being still remains an open question.

Our results agree with earlier studies stating that the effects of nature exposure depend on the outcomes (Bringslimark, Hartig & Patil, 2009). Vitality but not, for example, happiness was responsive to self-reported physical activity in nature over time. This is interesting as there is evidence that momentary happiness in natural

environments is greater than in urban environments (MacKerron & Mourato, 2013). One reason for our finding may lie in the fact that vitality had the lowest stability across one year; therefore there was more variance left to be explained for example by physical activity.

It is known that physical exercise increases vitality *per se* but, as yet, there is no clearly formulated theory regarding the specific features of the natural environment influencing vitality. Vitality may arise from different aspects of human-nature interaction than in attention or stress restoration. It is noteworthy that the association of exposure to the natural world with vitality was statistically significant (and marginally also for happiness), independent of work-related support, autonomy, workload, and the number of breaks. Thus they are likely based on different psychological mechanisms than relatedness, competence, and autonomy at work. Again, the processes of attentional and stress restoration may be operational but as we could not measure these mechanisms in the present study, the suggestions remain speculative. Future theoretical contributions and longitudinal studies focusing on these differences in affective effects are called for.

4.2. Hypotheses regarding the “reverse” and “reciprocal models”

The reverse model showed an almost equal fit with our data supporting H2 and suggesting that in this field of study, it is important to remember that mood and affective states may affect the choice between environments and thus nature exposure. In the reverse model, self-reported creativity at work predicted more frequent self-reported use of one’s yard/garden. It seems possible that people who feel more creative are inclined to select green housing environments or use them more often. In contrast to the “normal causation” where the more frequent use of one’s yard marginally predicted more happiness, more happiness, in turn, predicted more frequent physical activity in nature (marginally). Vitality predicted the less frequent use of one’s yard although more frequent physical activity in natural settings predicted stronger vitality in the “normal causation model”. It can be speculated that as frequent physical activity seems to be related to stronger vitality and happiness, more vital and happier people require and use more distant and larger natural areas than their home yard to be able to be sufficiently active. The reciprocal model (H3) got no support.

4.3. Limitations

A limitation of the present study includes using self-report measures for all variables, giving rise to concerns about common method variance (CMV). Temporally separating predictor and criterion variables, as in the present study, is one acceptable way of reducing the risk of CMV (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Despite this and the fact that we modelled simultaneously several nature exposure variables while controlling for theoretically important variables and even tested reverse and reciprocal models, causal claims require further research as our models were correlative. The one-year time lag between our measurements may not have been optimal and should be varied in future studies. Our selection was based on earlier research but also on the practical reality of busy organizational settings not allowing data collections within short time spans.

A further limitation of the present study and an option for future studies is that we were not able to measure the intensity of nature-based physical activity or the amount or quality of interaction with indoor plants during the working day. The test-retest reliability of our one-item measures was satisfactory (correlations between T1 and T2 ranging from 0.55 to 0.69). However, the validity of reporting, e.g., the use of the garden may be questioned, particularly if that use varies by season. Although the participants knew that the study was about recovery from work, the questionnaire included so many questions that it is unlikely that demand characteristics (guessing the relationships that were studied) bias the results significantly.

There was some selective attrition in our sample. Hence, the findings cannot be generalized to the working population as a whole; those more committed to their companies may have participated more likely. The results might look different in samples experiencing heavier workloads or operating in different sectors or cultural contexts.

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