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Nature exposure predicts well-being trajectory groups among employees across two years

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Abstract

We investigated relations between various types of self-reported nature exposure at work and at home, and well-being among employees (N = 664) across two years. An electronic questionnaire was delivered three times, once a year. We identified seven employee groups with different long-term trajectories of four well-being indicators (vitality, happiness, vigor and creativity at work). More frequent physical activity (PA) in natural surroundings during free time in the first measurement increased the odds of belonging to long-term "beneficial" well-being groups after including control variables. The decrease in using one's home garden decreased the odds of belonging to one beneficial well-being group suggesting a threshold level, the decrease of which may diminish the chances of better well-being longitudinally. The dose-response relationships and the role of personal agency in the interaction with the natural environment deserve further attention.

Keywords: nature exposure, hedonic, eudaimonic, well-being, longitudinal

1. Introduction

The impact of nature exposure on employees' well-being is not yet fully understood. The effects of different types of nature contact have not been sufficiently explored, longitudinal evidence is scarce, and there is lack of research on the relationship between nature exposure, hedonic (presence of positive affect) and eudaimonic (self-actualization) well-being (Capaldi, Passmore, Nisbet, Zelenski, & Dopko, 2015).

We aim to address these gaps by using a longitudinal design to identify combined courses, i.e., trajectories of hedonic (happiness, vitality) and eudaimonic well-being (vigor, creativity) across a prolonged period of time and connecting them to nature exposure at work and in leisure time. Different patterns of trajectories are anticipated as emotions are discrete entities for some individuals more than for others (Feldman Barrett, 1998).

1.1. Types of nature exposure and well-being

Longitudinal studies of nature exposure at workplaces are rare and have measured hedonic well-being (e.g. tiredness in response to plants, Nieuwenhuis, Knight, Postmes, & Haslam, 2014). Another finding from an 8-week intervention study among office workers showed that self-reported emotional health improved in the lunchtime nature walking group, but not in the built environment walking or control group (Brown, Barton, Pretty, & Gladwell, 2014).

The simultaneous effects of different types of nature exposure on well-being have been investigated rarely. Cross-sectional findings suggest that employees' self-reported use of nearby greenspace at their workplace and window views over greenspace were positively associated with well-being (e.g. positive feelings) after controlling for the free time use of garden and outdoor activity (Gilchrist, Brown, & Montarzino, 2015). An earlier study, on which the present study is based, found that self-reported physical activity (PA) in natural surroundings predicted greater vitality but not other aspects of well-being across one year

(Korpela, De Bloom, Sianoja, Pasanen, & Kinnunen, 2017; for the experimental part see De Bloom et al., 2017). Self-reported use of one's own garden/yard marginally predicted happiness. Exposure to the natural world at work did not predict well-being.

In summary, only a few benefits of nature exposure have gained reliable longitudinal support. As all of these include emotional, hedonic outcomes, we built upon these but expand this line of research to eudaimonic outcomes. A unique aim of this study is to look at the outcomes in combination in a person-centered approach (e.g. Bennett, Gabriel, Calderwood, Dahling, & Trougakos, 2016). This allows us to identify distinct groups of individual well-being trajectories and to understand whether subpopulations exist in the sample. This approach provides a more comprehensive view that would be missed when addressing only one well-being outcome at a time. Second, we predict these groups with several types of nature exposure simultaneously (ranging from viewing nature to being physically active in nature) including both work and leisure contexts.

1.2. Pathways from nature exposure to well-being

Nature exposure and well-being have been connected through 1) attention restoration, 2) stress restoration, 3) increased positive emotions, and 4) responses to specific health-enhancing conditions, such as noise (James, Banay, Hart, & Laden, 2015; Kuo, 2015). In addition, 5) behavioral mechanisms include increased PA, social interaction (Gascon et al., 2015), and healthier duration of sleep (Astell-Burt, Feng, & Kolt, 2013a). These pathways can be regarded as benefits as such, but also as mechanisms through which other, ensuing or related well-being benefits, such as higher vigor or creativity at work, might arise. In the following we derive our outcome indicators from the first three themes. The results connecting PA and gardening to well-being are discussed under “Study Aims”.

Attention restoration theory (ART) explains that nature, by modestly attracting attention in a bottom-up fashion, provides respite for the cognitive control processes,

restoring attention and promoting well-being (Berman, Jonides, & Kaplan, 2008). In a prolonged restorative experience, a person may end up in reflecting on personal matters in life (Kaplan & Kaplan, 1989). There is evidence of increased capacity of reflection on a minor life problem in natural versus urban environments after 10-15 minutes (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009). Importantly for employee well-being, reflection is an equivalent of "positive cognitive rumination" (i.e., thinking about solutions to a problem; Cropley & Zijlstra, 2011) which can reduce work-related fatigue (Querstret & Cropley, 2012), is linked to creative behaviors (Verhaeghen, Joormann, & Aikman, 2014), and predicts enhanced emotional well-being longitudinally (Fredrickson & Joiner, 2002).

The link between nature exposure and well-being is also apparent in the psychophysiological stress recovery theory (SRT; Ulrich, 1983). According to SRT, a visual encounter with natural scenes prompts a rapid, automatic shift towards positive emotional states. Viewing nature scenes for five minutes (Brown, Barton, & Gladwell, 2013) and short nature walks at lunchtime increase parasympathetic activity, even in the following night during sleep (Gladwell, Kuoppa, Tarvainen, & Rogerson, 2016). Parasympathetic activity induces relaxation contributing to long-term health (Kenney & Ganta, 2014).

1.3. Well-being outcomes: vitality, happiness, vigor, and creativity

We investigate hedonic and eudaimonic aspects of well-being that may co-occur or be corollaries of the documented short-term cognitive, emotional, and physiological effects. We include hedonic experiences of vitality and happiness. They are differentiated because *vitality* is characterized by high energy or activation ("enthusiastic"), not necessarily true of happiness ("content") (Nix, Ryan, Manly, & Deci, 1999). Vitality includes feelings of aliveness (Nix et al., 1999) that are more energized than feelings of relaxation (Ryan et al., 2010). Studies with photographs and 15-minute walks in nature have suggested that nature exposure has vitalizing effects (Ryan et al., 2010) providing a rationale for our selection of

this outcome. Vitality is important as such but also because of its relations to subsequent employee well-being through the more probable use of positive coping responses (Ryan & Deci, 2008).

Apart from vitality, there is a lack of studies addressing specific positive emotions as outcomes of nature exposure (McMahan & Estes, 2015). Some evidence is available for one of our outcomes, *happiness*. In a sample using mobile applications to report momentary feelings, the participants were happier in all natural habitat types compared with urban outdoor environments (MacKerron & Mourato, 2013). Moving to greener areas has been related to greater subsequent happiness and life satisfaction over several years (Alcock, White, Wheeler, Fleming, & Depledge, 2014).

As a novel contribution, we consider *vigor at work*. Vigor refers to high levels of energy while working, perseverance, and willingness to invest in one's work (Schaufeli, Salanova, González-Romá, & Bakker, 2002). Thus vigor includes eudaimonic, volitional aspects of "willingness to invest" but also the ability to direct attention ("perseverance") and energetic, hedonic feelings. As nature has a positive effect on both attention and emotions, we consider vigor to be an appropriate outcome.

We include *creativity at work*, defined as the production of novel ideas or solutions (Amabile, Barsade, Mueller, & Staw, 2005) as the fourth outcome (eudaimonic). There is evidence that creative problem solving improves after intensive nature exposure (Atchley, Strayer, & Atchley, 2012). Creativity is related to attention restoration and lower arousal in nature (Atchley et al., 2012) but also to positive mood and the consequent increase in insight and divergent associations (Shibata & Suzuki, 2002). Creativity at work as an outcome of nature exposure is under-researched although it has important connections to employee satisfaction and organizational innovation (Amabile et al., 2005).

1.4. Aims and hypotheses

We investigate the existence and heterogeneity of long-term trajectories of the four well-being indicators simultaneously.

Research Question 1: Do distinct trajectory groups of employees exist where happiness, vitality, vigor at work, and creativity at work vary quantitatively (in level) and qualitatively (in the shape of the trajectory over time)?

Our second aim is to predict trajectory groups with nature exposure.

Research Question 2: What are the relationships between the frequency of different types of nature exposure and well-being trajectory groups?

To contribute to the rare comparisons between different types of exposure to the natural world as predictors of well-being, we included exposure to the natural world at work, at home, and during leisure time. In a previous study, domestic garden and the frequency of participation in outdoor activities were controlled for but not the frequency of looking out of the windows or being in the garden (Gilchrist et al., 2015). Our nature exposure variables represent a perceived dimension of increasing immersion in natural surroundings and an increasing amount of PA, starting from sitting and looking at plants to being physically active outdoors.

To enhance ecological validity, we investigate the effects of nature exposure in a wider context than previously by controlling for the frequency of intensive PA and relevant job characteristics. The study by Gilchrist et al. (2015) accounted for work demands, job type, and full- or part-time working. We control for social support, job autonomy, and workload, which have been described in the Job Demand-Control (-Support) Model (Karasek & Theorell, 1990) and shown to be associated with well-being (Ilies, Dimotakis, & De Pater,

2010). Another previously uncontrolled variable is the number of breaks from work during the day. More breaks have been related to more vigor and less fatigue (Tucker, 2003).

We generate longitudinal conclusions by using a three-wave design. We administered our survey three times over two years, once a year, as earlier studies provide a 1-5-year range for the long-term effects of nature exposure on well-being. For example, green qualities around the residence in interaction with PA predicted mental health over a 5-year timespan for women (Annerstedt et al., 2012). A one-year lag between the two measurement points accords with existing longitudinal studies on greenspace and mental health where annual records of well-being have been used (Alcock et al., 2014; Astell-Burt, Mitchell, & Hartig, 2014). We speculate that the types of nature exposure in our study represent recurring loops of behaviors on a daily or weekly basis which will increase the likelihood of good well-being across two years.

On the basis of existing research, all types of perceived nature exposure at work and during leisure time could be positively related to well-being outcomes. However, our earlier two-wave study (Korpela et al., 2017) proposes two main hypotheses: Only the most intensive forms of nature exposure, that is, (self-reported) PA in nature (*H1*) and possibly gardening or the use of one's yard or patio including natural elements (*H2*), predict longitudinal well-being. As previous studies of this kind are nonexistent, we have no hypotheses of the number of trajectory groups.

H1 is based on the fact that PA in natural surroundings provides added benefits to PA as such (Rogerson & Barton, 2015). Experimental studies have found short-term positive effects of PA in nature on mood (Barton & Pretty, 2010; Thompson Coon et al., 2011), attentional performance, and physiological processes (Hartig, Mitchell, deVries, & Frumkin, 2014). According to surveys, PA in nature has more positive effects on emotional well-being than activity indoors or outdoors in built environments (Pasanen, Tyrväinen, & Korpela, 2014). In

a cross-sectional population level study, time spent visiting green spaces was associated with better mental health and vitality (van den Berg et al., 2016). Regarding employees, a cross-sectional survey study found a link between PA in nature and less need for recovery from work (Korpela & Kinnunen, 2011).

Concerning *H2*, only one study has included an employee sample and a longitudinal design (Sahlin et al., 2014). This study investigated a 12-week nature-based stress management course including gardening (and nature walks). Decreased burnout scores and fewer sick leaves for female employees at the end of the course, and in the 6- and 12-month follow-ups were reported. A study that quantified green space provision in several urban and rural areas found support for domestic gardens as a buffer against poor health (Dennis & James, 2017). Domestic gardens were more strongly negatively associated with local area health deprivation (including mood disorders) than public green space.

2. Method

2.1. Sample and Procedure

The participants were employees from eleven organizations (education, information technology, and media) that were located near well-maintained urban parks. The questionnaire data were collected in three waves. First, 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 contact persons, usually the HR manager (in four organizations). Of the employees contacted (N = 3,593), 1,347 returned the completed questionnaire after two reminders (response rate 37.5%). Second, in spring 2014 (Time 2) another electronic questionnaire was sent to those employees who responded in 2013 and who were still in the employ of the same organizations (N = 1,192). A total of 841 employees returned the completed questionnaire (response rate 70.6%). Third, in spring

2015 (Time 3) the third electronic questionnaire was sent to those who had responded in 2013 and 2014, and who were still employed by the same organizations (N = 799). Of these, 664 employees responded (response rate 83.1%). In every phase of the study the employees received information about the goals of the study ("a longitudinal study about recovery from work including a 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.

At Time 1 of this longitudinal sample (N = 664), the participants' average age was 47.5 years (range 23–66, SD = 9.9). Of the sample, 58% were women; 38% held an academic degree (master's level or higher), 26% had a polytechnic degree, and the rest (36%) had a vocational school qualification or less. The majority of the sample (62%) were higher white-collar workers (e.g., teachers), 29.5% were lower-white collar workers (e.g., office workers), and 8.5% were blue-collar workers (e.g., cleaners). Most employees had a permanent job (91%), worked full-time (97%), and worked a regular day shift (90%). Average hours worked weekly were 39 (SD = 5.9) and 13% of respondents were in managerial positions. Of the participants, 54.5% worked in the public sector, and the rest (45.5%) worked in the private sector. Most of the participants (80%) were living with a partner (either married or cohabiting), and 44.2% had some children (average of two) living at home.

2.2. Sample Attrition

We compared the characteristics of the respondents of the long-term sample with the dropouts (non-respondents either at T2 or at T3). The respondents did not differ from the dropouts in terms of gender, education, occupational status, weekly working hours, managerial position, having a partner, or number of children. However, the respondents more often had a permanent employment contract (91% vs. 80%, $p < .001$), worked more often on a

regular day shift (90% vs. 85%, $p < .05$), and were slightly older (47.5 vs. 46.2 years, $p < .05$) than the non-respondents.

The longitudinal sample did not differ from the dropouts in terms of the nature exposure and outcome variables except that the longitudinal sample reported more vigor (4.6 vs. 4.4, $p < .05$) at T1. The respondents of the longitudinal sample also reported more autonomy (3.2 vs. 3.1, $p = .001$) and support (4.0 vs. 3.9, $p < .05$) and had more breaks (2.5 vs. 2.4, $p = .05$) at T1 than the dropouts.

2.3. Measures

All the variables used in this study were measured at time points T1, T2, and T3. In the variable descriptions, we primarily present the recoded response categories (used in the statistical analyses) in text and the corresponding original categories in brackets.

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. For the multinomial logistic regressions (see "Statistical Analyses"), the coding was 0 = 0 plants, 1 = 1-3, and 2 = 4-30 plants.

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 looks onto the inside of the building", 3 = "Yes, it looks onto the outside of the building with a mainly urban view (for example a building or street)," and 4 = "Yes, it looks onto the outside of the building with a mainly natural view (for example a lake, field, or park)". For the multinomial logistic regressions, type of view was coded: 1 = nature view (4), 2 = inside view (2), urban view (3), or no view (1). If the respondent reported not having a

permanent room or work station (at T1 and T2 9.1%, at T3 6.5% of the sample), the values for the window view were imputed as 2 and the number of plants as zero.

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 out of the window *per se* but thought that people might more easily recognize the moments when they felt elevated after looking at their surroundings. We asked "To what extent do you use each of the behaviors to manage your energy during your working day?" Among a list of 13 behaviors we included "Look out of the window". The original response scale ranged from 1 to 5 and it was coded for the multinomial logistic regressions as 1= "very seldom or never (1), or rather seldom" (2), 2 = "sometimes" (3), 3 = "rather often" (4), or "very often or always" (5).

Nature exposure variables at home and in 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 that were coded for the multinomial logistic regressions as 1 = "No (0), or Yes, and I look at /use it fairly seldom" (1), 2 = "Yes, and I look at /use it sometimes" (2), 3 = "Yes, and I look at /use it often" (3).

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 four response categories were coded for the multinomial logistic regressions as 1 = "No (0), or Yes, but I seldom use it" (1), 2 = "Yes, and I sometimes use it" (2), 3 = "Yes, and I often use it" (3).

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 a list of seven activities. The response categories were recoded for the multinomial logistic regressions as 1 = “Hardly ever or a few times per year (1), About once per month” (2), or A few times per month” (3), 2 = “About once per week” (4), 3 = “A few times per week (5), or Almost every day” (6).

The temporal changes in the nature exposure variables were calculated as T2* = T2-T1 and T3* = T3-T1 differences. The change was categorized as -1 = decrease in the number or frequency or change in the type of view from the window, 0 = no change, and 1 = increase in the number or frequency or change in the type of view from the window. Variables T2* or T3* were set at zero if T1, T2 or T3 were missing.

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).

Vitality was measured with four items from the Subjective Vitality Scale (Bostic, Rubio, & Hood, 2000) (e.g. “During the last month, I have felt alive and vital”). 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”) 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”) (George & Zhou, 2001) rated on a scale from 1 (very seldom or never) to 5 (very often or always). For the trajectory analysis, the items of vitality, vigor, and creativity were dichotomized so that scale values greater than 3 were set at 1 and

the other alternatives were set at zero. Thus, no Cronbach's alphas are reported for these variables.

Control variables. *Frequency of intensive PA* was measured with one item "Exercising at least 20 minutes with getting at least slightly out of breath and sweating" rated on a 6-point scale recoded to three categories for the multinomial logistic regressions (see variable Frequency of physical activities in natural surroundings).

Job autonomy was measured with five items (e.g., "I can influence the amount of work assigned to me". Cronbach's alpha at T1 = .78, at T2 =.79, and at T3 =.77) 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 from both colleagues and supervisors (6 items) was .80 at T1, .82 at T2, and .83 at T3. 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 at T1 =.88, at T2 =.87, and at T3 =.87) 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 minutes 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* in line with an earlier study (Gilchrist et al., 2015).

2.4. Statistical analyses

To understand the heterogeneity of multidimensional longitudinal data, our approach is based on a trajectory analysis (TA) by Nagin (1999; 2005) and Jones et al. (2001) that applies generalized linear models theory (exponential family of distributions) with Finite Mixtures under the assumption that observations within a given trajectory are independent. We applied the multivariate version of this basic TA, where outcomes are related but independent response variables (see Jones & Nagin, 2007; Nagin 2005) using the R program Flexmix (Leisch, 2004).

The analysis involves technical challenges in terms of probability distributions, measuring issues, and missing data. However, we wanted to keep the analysis as simple and accurate as possible, so that all the available longitudinal information was used simultaneously making the results easy to interpret and compare. The eleven response variables for multivariate TA in our study were four items for vitality, one item for happiness, three items for vigor, and three items for creativity. Instead of summary scores of well-being variables we used single items so that the complete longitudinal information could be used in trajectory group formation. However, for simplicity and due to the limitations of the probability distributions available in R program Flexmix, the items of vigor, creativity and vitality measures were dichotomized (see Measures). This yielded an 11-variate mixture regression model with ten logistic variables and one normal (happiness) response variable that were studied as a function of time. Acceptable nested model fits were assessed with the Bayesian information criterion (BIC) criterion, the smallest indices indicating the best model fit (Schreiber, Stage, King, Nora, & Barlow, 2006).

The associations of nature exposure and other background variables with trajectory groups were studied in a multinomial logistic regression model (SPSS version 22.0). In the model, nature exposure at T1 and changes in the nature exposure variables T2* = T2-T1 and T3* = T3-T1 were used as explanatory variables jointly with the control variables intensive

PA, job autonomy, social support, workload, gender, and age. For the multi-item scales of autonomy, support, and workload we first calculated the mean summary scores at each time point. The mean values across the three measurement points of intensive PA and the multi-item scale scores were used in the regression analysis. Since the trajectory groups are based on probabilities, the observations in multinomial regression analyses were weighted with the posterior probability of belonging to the most likely trajectory group.

3. Results

3.1. Descriptive Statistics

Tables 1a-1e (Appendix) show the zero-order correlations between the variables. As anticipated, all nature exposure variables had some significant positive correlations with the well-being variables both cross-sectionally (ranges of r = .03 - .19 at T1; r = .01 - .16 at T2; r = .001 - .20 at T3) and longitudinally (r = .01 - .23). However, looking out of the window at nature at home, use of home yard/garden, and PA in nature had consistently the largest correlations with the well-being variables cross-sectionally and longitudinally. Well-being indicators correlated with each other positively and significantly at all time points both cross-sectionally (r = .15 - .63 at T1; r = .17 - .65 at T2; r = .16 - .66 at T3) and longitudinally (r = .10 - .77).

There were weak correlations (ranges of r = .02 - .19 at T1; r = .001 - .18 at T2; r = .02 - .23 at T3) between the nature exposure variables, the strongest ones being for making use of a nature view at home and of a garden, balcony, or yard with nature elements at home (r = .50 at T1; r = .52 at T2; r = .53 at T3), suggesting non-existent multicollinearity. The correlations between the nature exposure variables and control variables were likewise weak (r = .001 - .29 at T1; r = .001 - .25 at T2; r = .001 - .22 at T3). The correlations between job-related control variables (autonomy, support, workload, breaks) and well-being variables were of

moderate strength and mostly significant cross-sectionally (r = .001 - .37 at T1; r = .03 - .36 at T2; r = .01 - .44 at T3) and longitudinally (r = .01 - .38).

3.2. Identifying well-being trajectory groups

We tested the number of trajectory groups from one to nine such that each run was repeated ten times. The Bayesian information criterion (BIC) values obtained were 31273.92, 27192.51, 26267.89, 25615.51, 25240.37, 25047.48, 24968.11, 24990.04 and 25043.17. This shows that the best, i.e., the minimum value (24968.11) of BIC (Schreiber et al., 2006) is obtained when the number of groups is seven. The rootogram plot of posterior probabilities (Appendix) shows that groups are very well separated. All the groups have a meaningful size with mixture proportions: p1 = 0.1146, p2 = 0.2136, p3 = 0.1586, p4 = 0.1158, p5 = 0.1316, p6 = 0.0995 and p7 = 0.1664. These can be interpreted as percentages of the sample belonging to the group, e.g., 0.1146 = 11.46% (Fig. 1). For clarity and ease of interpretation, in drawing Figure 1 of trajectory groups, we used the summary scores of the three dichotomized multi-item well-being indicators (vitality, vigor, and creativity) so that each group includes four well-being indicators only.

In general, the major differences between the trajectory groups were in the absolute level of the four well-being indicators and their differing combinations rather than in the shapes of the slopes across time. For the following descriptions of the trajectory groups (Fig. 1), all four indicators and their relative scores were evaluated approximately and simultaneously.

Group 1 (low, declining well-being) – Quite high score for happiness associated with moderate and declining but then leveling out score for feeling vigorous at work. Feelings of creativity and vitality have relatively low scores which decline somewhat to T2 and level after that.

Group 2 (high well-being but low creativity) – Very high score on feeling vigorous at work associated with a steadily high score on happiness. The score for feeling vital is moderate and quite steady. Quite low and decreasing score of feeling creative at work. This group comprising 21.4% of the participants was the largest and most typical in our sample.

Group 3 (high well-being, especially creativity) – Moderately increasing, very high scores for feeling vigorous and creative at work associated with moderately increasing, fairly high scores for happiness. There is a moderate, steady score for feeling vital. On the whole, this group might be labeled "moderately increasing well-being".

Group 4 (poorest well-being; reference group in multinomial logistic regressions) – Quite steady and low scores for feeling vigorous, creative or vital. Steady but only moderate score for feeling happy.

Group 5 (highest well-being) – Steady and very high scores for feeling vigorous, happy and vital. High but somewhat decreasing score for feeling creative at work.

Group 6 (average but decreasing well-being, low vitality) – High but declining score for creativity associated with moderate score for feeling happy. Moderate and declining but then leveling score for feeling vigorous at work. Low and somewhat declining score for feeling vital. This group was the smallest (9.95%) and thus most atypical in our sample.

Group 7 (high vigor, low creativity and vitality scores) – Very high, slightly increasing score for feeling vigorous at work associated with fairly high, steady score on happiness. Rather low but somewhat increasing score for feeling creative. Steady, low score for feeling vital.

To sum, across all trajectories, the score for happiness was most consistently on a high ($> .70$) or moderate ($.40 < \text{score} < .70$) level. Thus, our sample consists of quite happy

employees. The steepest slopes (decreases) were in vigor (trajectory groups 1 and 6). Thus, these two groups are characterized by a declining vigor at work and moderately low levels of vitality across two years. Groups with clear increases in well-being (all four indicators) were not detected although group 3 had moderate increases in happiness, vigor, and creativity. This group together with group 5 are groups with high overall vigor and creativity at work who also are generally happy and vital. Groups 2 and 7 have low levels of vitality and creativity at work but are otherwise happy and vigorous. Group 4, the reference group in multinomial regression, is clearly at the lowest level in vigor, creativity, and vitality and only moderately happy.

3.3. Predicting well-being trajectory groups with nature exposure

The multinomial logistic regression model with control variables and nature exposure variables as predictors fitted the data well (*Pearson's* $\chi^2(3576) = 3389$, $p = .99$; *Nagelkerke* $R^2 = .59$). For ease of reading, the results of this single regression analysis are presented in three separate tables (Tables 2a-c).

In accordance with our main hypothesis, the most consistent, positive, nature-related predictor of the trajectory groups after controlling for covariates was PA in nature (Tables 2a-c). Those who were more frequently physically active in nature (more than once a week) had at least three times higher conditional odds (Table 2a; $3.8 \leq Exp(B) < 25.3$; $.001 < p < .05$) for belonging to the happier and/or more vigorous and vital trajectory groups (1-2 and 5), i.e., "beneficial groups" than to the "lowest well-being" group 4. The most notable increase in odds, 25-fold, was in the most positive trajectory group 5 having high scores on all four experiences of happiness, vigor, vitality, and creativity. In that trajectory group, being physically active in nature once a week increased the odds 5-fold compared with PA less than

once a week. However, PA in nature did not predict groups 3 with moderate, and groups 6 and 7, with low scores for vitality.

Nature-exposure variables at work had unexpected relations to the trajectory groups. The greater the number of plants in a work room/station the lower were the conditional odds (Table 2a; $.17 \leq Exp(B) < .29$; $.007 < p < .05$) for belonging (in reference to the trajectory 4) to the "beneficial groups" 1, 3, 5, and 6, which had high scores on happiness. Groups 1, 3, and 6 had also medium or low scores for feeling vital. Moreover, increase in the number of plants from T1 to T2 decreased the odds of belonging to groups 1, 2, 5, and 7 whereas no such trend was observed of the increase in the number of plants from T1 to T3 (Table 2b). Looking out of the window at work at T1 often rather than seldom was associated with low conditional odds of belonging to the group 6 (average but decreasing well-being, low vitality) (Table 2a). Those looking out often at T1 were more likely to have a natural view ($f = 55$) than an urban or indoor view ($f = 151$) than those looking out seldom ($f = 30$ and 149, respectively), a significant association ($\chi^2_{(1)} = 5.5$, $p = .02$).

Views from the window at work at T1 did not predict the odds of belonging to the groups (Table 2a) but the change from T1 to T2 in the view from the window at work away from nature to urban (incl. indoor or no view) decreased the odds of belonging to groups 1 and 7 (Table 2b), which both included high score on happiness.

Unexpectedly, the change from an urban (incl. indoor or no view) to a natural view at work decreased the conditional odds of belonging to group 2 with high scores on happiness and vigor (Table 2b). Again unexpectedly, the change from T1 to T3 in the view from the window away from nature to urban, indoor or no view hugely increased the conditional odds of belonging to the "beneficial groups" 1, 2, 5, and 6; for the most positive group 5 (having high scores on all four experiences of happiness, vigor, vitality, and creativity) the odds were

84-fold (Table 2b). To understand this unexpected result, we checked the change in the type of work room from T1 to T3 among those who had an urban view at T3 (n = 496). Of those, 6.7% (4.8% < *CI95%* < 9.2%) at T1 reported that their work room varied but no-one (0% < *CI95%* < 0.8%) reported this at T3; a significant difference as the confidence intervals do not overlap. Moreover, there were other changes in a similar direction although non-significantly: 24.2 % (20.6% < *CI95%* < 28.2%) had a work room of their own at T3 versus only 21.2% (17.8% < *CI95%* < 25.0%) at T1. There was an increase in having a permanent classroom among teachers; 4.0% (2.6% < *CI95%* < 6.1%) at T3 versus 3.4% (2.2% < *CI95%* < 5.4%) at T1. The share of those sharing a room but with a desk of their own also increased from 65.9% (61.7% < *CI95%* < 70.0%) at T1 to 68.1% (63.9% < *CI95%* < 72.1%) at T3. We speculate that these changes, i.e., decrease in changes in work rooms and increases in personal and permanent working rooms/ desks, may explain the increased odds of belonging to "beneficial" trajectory groups even though the window view changed from natural to urban.

Regarding nature exposure at home, unexpectedly, using the garden/home yard at T1 more frequently, i.e., sometimes rather than seldom, decreased the conditional odds of belonging to group 3 (Table 2a) with steady, very high scores on vigor, creativity, and happiness (in reference to the lowest well-being group 4). However, the conditional odds of using the garden and looking out at nature at home often rather than seldom were mostly greater than 1, but they were not statistically significant. In accordance with our expectations, however, the decrease in the use of home yard (from T1 to T3) decreased the conditional odds of belonging to group 5 (Table 2b) with very high scores for feeling vigorous, happy, vital, and creative (in reference to group 4).

3.4. Control variables as predictors

Of the control variables, social support increased the conditional odds of belonging to all groups, most notably to group 5, which includes high scores on all four experiences, in reference to group 4. Autonomy at work increased the conditional odds of belonging to the "beneficial" groups 2, 3, and 5, whereas workload increased the odds of belonging to group 3 only. Being female increased the odds of belonging to the "highest well-being" group 5 but also to group 7 with low vitality and creativity.

4. Discussion

We were able to identify trajectory groups based on long-term individual developments of happiness, vitality, vigor, and creativity indicators that differed in the levels rather than in the shape of the temporal trend. Happiness had most consistently high or moderate level scores at all time points, which accords with findings of considerable stability in happiness and the finding that different types of well-being may change at different rates or directions (Diener, Lucas, & Scollon, 2006). The least beneficial trajectory group had a moderate, steady level of happiness and steadily low levels of other well-being experiences (11.6% of participants). The most beneficial trajectory group had high and steady levels of all four well-being indicators (13.2% of participants). Other trajectory groups were combinations of the levels between these two extremes. Thus, in some trajectory groups, all indicator trajectories were densely packed at the high or low end of the scores, whereas in others the four indicators were widely dispersed along the scale. These results support the notion of individual variation in the experience emotion clusters (Feldman Barrett, 1998).

Consistent with *H1* we observed that the more frequent nature activity at T1 *increased* the conditional odds of belonging to the long-term "beneficial" groups in relation to the least beneficial group, independently of the frequency of intensive PA, job characteristics, age or gender. These beneficial groups included the most beneficial one (5), where all four experiences, including aspects of both hedonic and eudaimonic well-being, were on a high

level; all others (1-3) had a high level of happiness but two had low levels of creativity (eudaimonic well-being). The result supports the notion that nature exposure works via or together with PA to promote well-being (Annerstedt et al., 2012) but the long-term effects of the changes in nature PA remain unknown as these changes were unrelated to the odds.

At T1, using the home garden/yard more often decreased the odds of belonging to one of the "beneficial" trajectory groups (group 3) which contradicts our hypothesis *H2* and does not accord with gardening being related to better well-being among adults (Wang & Macmillan, 2013). However, the decrease in using one's home garden or yard over time was associated with low odds of belonging to the "beneficial" group (5) which is supportive of *H2* but in an unanticipated direction. This result suggest a *threshold* effect where the decrease in nature exposure under a certain level starts may lead to deprivation of well-being.

All other results were in an unexpected direction. The larger number of plants at work at T1 and its increase over one year were consistently related to the decreased odds of belonging to "beneficial" groups; a result defying clear interpretations as the trend disappeared after two years. Changes in window views from natural to urban and vice versa were associated with low odds of belonging to "beneficial" groups. Moreover, the change in the window view at work from natural to urban significantly increased the odds of belonging to "beneficial" groups. A technical check implied that increases in personal and permanent working rooms/ desks and decrease in having to change work rooms may explain this result.

At T1, looking out of the window at work often rather than seldom was associated with the low odds of belonging to one "beneficial" group (6) (but not others making the result inconsistent) although those looking out often were more likely to have a natural view than those looking out seldom. However, 65% of those looking out often had an urban, indoor or no view. Speculatively, irrespective of the type of the window view, if a working person

looks out often the work may be boring which diminishes well-being. In fact, little is known about the role of *personal agency* in and the *control* of the interaction with the natural environment. This is due to a focus on bottom-up processing of perceptual properties of nature in existing theories on restorative environments (Ratcliffe & Korpela, 2016). However, evidence suggests that people use their environment as a coping and self-regulation mechanism (Korpela, 2012). Future research could investigate the differential effects of plants brought by workers versus provided by the company or of the personal maintenance of plants on well-being.

Relevant to our results is the dose–response modeling that describes how individuals respond to nature exposure, whether that be measured as duration, frequency, or quality/type of nature (Shanahan, Fuller, Bush, Lin, & Gaston, 2015; Shanahan et al., 2016). In accordance with the concept of an increase in dose, we found that PA in nature predicted increased odds of belonging to several beneficial trajectory groups, thereby suggesting that it can serve as *an enhancer, a promoter* of well-being. The present results showed a negative predictive power of the decrease in the use of garden/yard suggesting that dose-response modeling should focus on both directions between dose and response. It is not known whether a decrease in nature dose can leave well-being on its earlier level or diminish it. How long need the decrease in dose to persist before the deterioration in well-being begins? Does increase in nature dose produce positive effects at similar temporal rates as the decrease exacerbates them? Future studies are needed to scrutinize such questions.

As the nature exposure variables did not predict the odds of belonging to all trajectory groups but only to some, we conclude, as in earlier studies, that the benefits of nature exposure depend on the outcomes (Bringslimark, Hartig, & Patil, 2009; Shanahan et al., 2016). However, we also maintain that the benefits depend on the constellations of the outcomes. For example, PA in nature at T1 most strongly predicted belonging to the most

beneficial well-being trajectory group (5). On the other hand, the trajectory group with high values on all other outcomes except vitality (3) and the group with low vitality and creativity but high vigor (7) had the smallest number of significant nature exposure predictors, thus being the most difficult ones to predict. As little is known about the effects of nature exposure on simultaneous combinations of emotions and aspects of well-being, future longitudinal studies focusing on these issues are important.

4.1. Limitations

Using self-report measures for all variables gives rise to concerns about common method variance (CMV) (Richardson, Simmering, & Sturman, 2009). Temporal separation of 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 included temporal changes in our predictor variables and modeled simultaneously associations of several plausible “causes” while controlling for relevant variables, causal claims require further research as our models were correlative and due to the large number of variables may include coincidental results. The time-lag should be varied in future studies.

A further limitation of the present study is that we were not able to measure the amount or type of interaction with nature during the working day. The test-retest reliabilities of our one-item measures were satisfactory (correlations between T1 and T2 were .52 - .68, between T1 and T3 .47 - .67, and between T2 and T3 .57 - .72). However, the validity of self-reports of the frequency of using the garden, for example, particularly if that varies by season, is not known. The participants knew that the study was about recovery from work but both the questionnaire and a time lag between the questionnaires were quite long, making demand characteristics (guessing the research question) as a biasing factor unlikely.

Concerning selective attrition from the first to the third measurement point, the non-respondents were more often e.g. younger, on temporary employment contracts, and working irregular shifts. Hence the findings cannot be generalized to the working population as a whole.

4.2. Practical implications

Acknowledging the limitations of a self-report, correlational study, we found that more frequent PA in natural surroundings during free time at the first measurement increased the odds of better well-being over a two-year period. This relationship held independent of the frequency of intensive PA, job autonomy, social support at work, workload, number of breaks during the workday, age or gender. Thus, promoting employee well-being by recommending and rewarding nature-based, free-time physical activities is an option to consider in knowledge-intensive workplaces if the causality of this relationship is verified in future studies. However, PA in nature did not predict trajectory groups with low vitality suggesting a need to tailor workplace interventions for different groups (Nielsen, Taris, & Cox, 2010).

The decrease of using one's home garden or yard with natural elements decreased the odds of better well-being. This, if proven more reliably, suggests that domestic gardens deserve to be maintained in urban structure as there may be a threshold level of their use protecting against the incidence of poor well-being in the long run (cf. Dennis & James, 2017).

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Table 2a. Conditional odds (significant in bold face) of the nature exposure variables at time 1 from multinomial logistic regression for seven trajectory groups ("traj. group"), the reference category being trajectory group 4 ("lowest well-being").

Time 1		Traj. group 1		Traj. group 2		Traj. group 3		Traj. group 4		Traj. group 5		Traj. group 6		Traj. group 7	
		Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
	Intercept[1]		.016		.000		.000	ref			.000		.004		.000
Number of plants (work)	> 3 plants	**.294**	**.050**	.573	.310	**.217**	**.016**	ref		**.275**	**.051**	**.166**	**.007**	.458	.156
	1-3 plants	.760	.593	1.047	.922	.550	.256	ref		**.258**	**.021**	.483	.172	.792	.629
	No plants							ref							
Window view (work)	Nature	1.367	.705	1.264	.759	2.975	.173	ref		.720	.713	1.342	.722	1.743	.468
	Urban/indoors/no							ref							
Looking out (work)	Often	.864	.806	.524	.232	.398	.141	ref		.485	.276	**.258**	**.026**	.383	.083
	Sometimes	1.322	.614	.849	.747	.657	.456	ref		.820	.742	.654	.442	.862	.773
	Seldom							ref							
Looking out, nature (home)	Often	1.294	.753	2.614	.209	5.159	.071	ref		5.370	.095	4.004	.108	2.866	.165
	Sometimes	.833	.774	.936	.910	1.497	.574	ref		.513	.373	1.041	.952	1.348	.603
	Seldom							ref							
Garden/balcony usage (home)	Often	1.297	.740	2.459	.230	1.260	.772	ref		.721	.707	1.049	.950	.664	.568
	Sometimes	.718	.613	1.839	.339	**.176**	**.012**	ref		.473	.317	.612	.458	1.094	.878
	Seldom/no							ref							
Physical activity in nature	> Once a week	**3.844**	**.050**	**3.958**	**.025**	**3.130**	**.104**	ref		**25.272**	**.000**	1.282	.715	2.310	.176
	Once a week	1.055	.928	1.153	.789	.766	.673	ref		**5.181**	**.034**	.562	.331	1.015	.979
	< Once a week							ref							

Note. 1: Tables 2a-2c are from a single, multinomial regression analysis. Intercept reported only in the Table 2a. If *Exp(B)* > 1 there is an increased conditional odds (and for *Exp(B)* < 1 decreased conditional odds) of belonging to that group in comparison to the reference group (ref) 4 "Lowest well-being". Among the predictors, the category followed by an empty row (e.g. no plants) is a reference category. For example, physical activity in nature more often than once a week in relation to less than once a week results in 3.844 times larger conditional odds of belonging to the trajectory group 1 rather than to group 4.

Table 2b. Conditional odds (significant in bold face) of the changes (from T1 to T2 and from T1 to T3) of the nature exposure variables from multinomial logistic regression for seven trajectory groups ("traj. group"), the reference category being trajectory group 4 ("lowest well-being").

		Traj. group 1		Traj. group 2		Traj. group 3		Traj. group 4		Traj. group 5		Traj. group 6		Traj. group 7	
		Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Changes in the number of plants T2-T1	Negative	.814	.765	.549	.352	.829	.790	ref		.979	.978	.523	.424	.621	.478
	Positive	**.154**	**.008**	**.133**	**.002**	.433	.200	ref		**.172**	**.027**	.364	.139	**.201**	**.011**
	No change							ref							
Changes in the number of plants T3-T1	Negative	1.167	.817	.779	.687	1.644	.475	ref		1.069	.927	1.120	.883	.605	.444
	Positive	2.102	.231	1.824	.312	.901	.880	ref		.912	.907	.447	.296	.935	.915
	No change							ref							
Changes in window view (work) T2-T1	From nature to urban	**.097**	**.046**	.170	.089	.253	.197	ref		.138	.104	.184	.149	**.091**	**.040**
	From urban to nature	.318	.144	**.219**	**.034**	.281	.110	ref		.248	.114	.235	.104	.534	.383
	No change							ref							
Changes in window view (work) T3-T1	From nature to urban	**30.50**	**.021**	**33.394**	**.012**	13.537	.069	ref		**84.489**	**.004**	**20.139**	**.049**	8.502	.174
	From urban to nature	2.852	.182	2.225	.301	.833	.845	ref		3.896	.150	.694	.738	1.282	.756
	No change							ref							
Changes in looking out of the window T2-T1	Negative	**.322**	**.058**	.457	.145	.566	.358	ref		.586	.399	.375	.148	.645	.424
	Positive	.728	.572	.756	.586	.905	.861	ref		.380	.123	1.217	.721	.699	.490
	No change							ref							
Changes in looking out of the window T3-T1	Negative	1.441	.518	1.016	.976	1.968	.244	ref		1.106	.878	1.319	.648	.901	.852
	Positive	1.175	.772	1.043	.934	1.158	.797	ref		1.769	.350	.478	.190	.862	.773
	No change							ref							

Table 2b continued

Changes in looking out at nature (home) T2-T1	Negative	.244	.079	.549	.338	.296	.114	ref	.581	.518	.612	.474	.363	.130
	Positive	.623	.536	0.974	.970	2.423	.284	ref	1.012	.990	.897	.893	1.221	.767
	No change							ref						
Changes in looking out at nature (home) T3-T1	Negative	.921	.914	0.984	.981	1.230	.788	ref	.725	.712	.808	.779	.847	.814
	Positive	.997	.997	1.043	.948	.369	.205	ref	2.041	.435	1.849	.425	.960	.950
	No change							ref						
Changes in garden/balcony usage T2-T1	Negative	1.231	.741	1.143	.813	1.675	.424	ref	.861	.838	1.860	.324	1.066	.915
	Positive	.938	.925	.970	.960	1.675	.454	ref	.869	.852	.822	.775	.521	.278
	No change							ref						
Changes in garden/balcony usage T3-T1	Negative	.614	.412	.853	.764	.292	.063	ref	**.160**	**.020**	.640	.469	.851	.772
	Positive	.823	.789	.579	.425	.918	.910	ref	.849	.835	.933	.926	1.147	.831
	No change							ref						
Changes in nature exercise T2-T1	Negative	1.488	.515	1.456	.514	.595	.428	ref	1.250	.740	1.339	.662	1.438	.541
	Positive	1.692	.392	.927	.894	.557	.380	ref	2.232	.294	.974	.965	1.037	.949
	No change							ref						
Changes in nature exercise T3-T1	Negative	1.335	.629	.716	.556	.689	.559	ref	.737	.644	.797	.733	1.206	.742
	Positive	1.876	.298	1.776	.291	1.290	.681	ref	0.944	.939	1.360	.600	1.337	.603
	No change							ref						

Table 2c. Conditional odds (significant in bold face) of the control variables from multinomial logistic regression for seven trajectory groups ("traj. group"), the reference category being trajectory group 4 ("lowest well-being").

		Traj. group 1		Traj. group 2		Traj. group 3		Traj. group 4		Traj. group 5		Traj. group 6		Traj. group 7	
		Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Age		.992	.725	.995	.807	1.001	.953	ref		1.023	.354	.988	.607	.977	.253
Workload		1.112	.723	1.306	.337	**4.354**	**.000**	ref		1.459	.252	1.747	.080	1.571	.121
Autonomy		1.232	.522	**2.136**	**.011**	**7.308**	**.000**	ref		**5.699**	**.000**	1.770	.087	1.639	.105
Support		**3.155**	**.002**	**7.876**	**.000**	**7.217**	**.000**	ref		**44.972**	**.000**	**3.338**	**.002**	**6.102**	**.000**
Breaks		1.186	.451	1.270	.258	1.276	.297	ref		1.277	.318	1.188	.466	1.214	.385
Intensive physical activity	> Once a week	1.615	.456	1.435	.530	1.582	.489	ref		1.810	.434	1.384	.606	1.102	.865
	Once a week	1.568	.481	.966	.953	1.781	.377	ref		1.177	.835	1.348	.628	1.066	.912
	< Once a week							ref							
Gender:	Female	2.269	.066	2.109	.069	1.614	.291	ref		**2.961**	**.027**	2.026	.124	**4.860**	**.000**
	Male							ref							

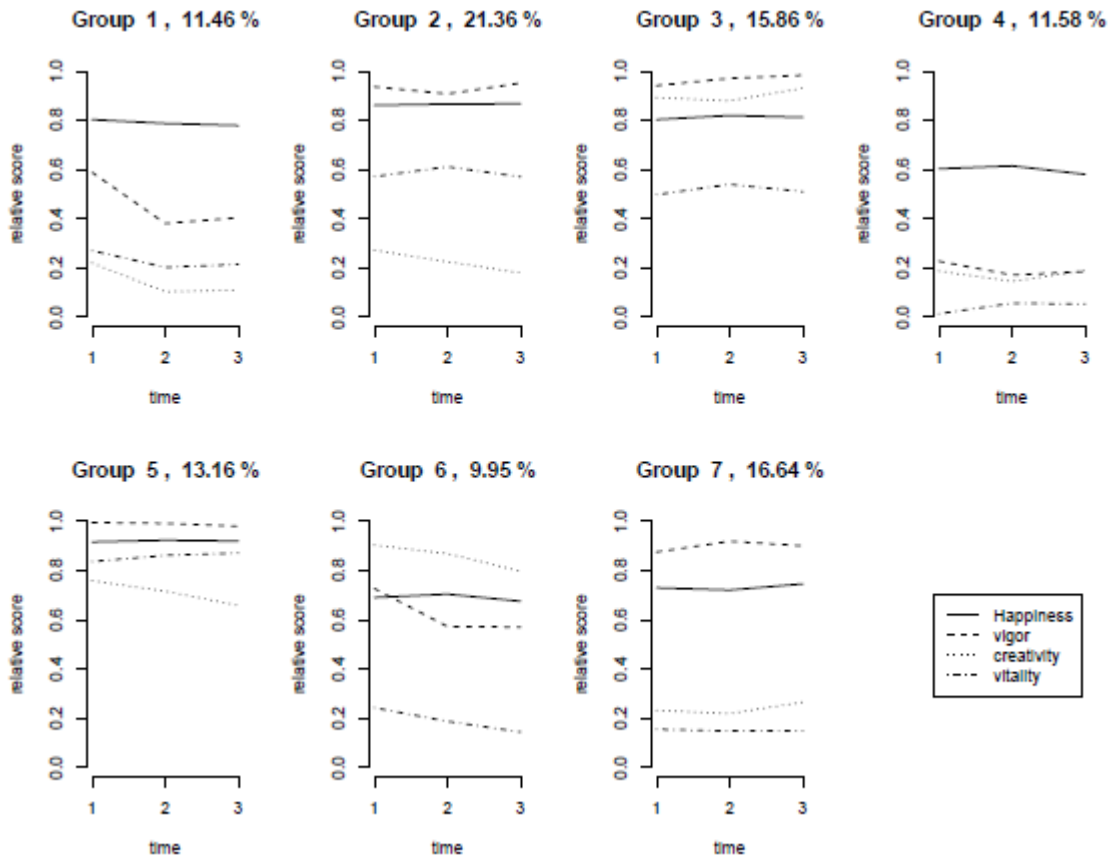

Figure 1. Relative scores of one-item happiness and summary scores for vigor, creativity, and vitality in the seven trajectory groups, and group proportions of the sample. Y-axis: relative score (max/score), ranging from 0 to 1. X-axis: measurement points 1, 2, and 3.

Highlights

- Exposure to nature at work and at home is related with well-being longitudinally.
- We identified developments in vitality, happiness, vigor, and creativity.
- More frequent nature-based physical activity increased odds of better well-being.
- Decrease in using a domestic garden decreased odds of better well-being.