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Vitalizing effects of being outdoors and in nature

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ABSTRACT

Five studies utilizing survey, experimental, and diary methods assessed the effects of being outdoors on subjective vitality. In Study 1, we used a vignette method to examine whether being outdoors was associated with vitality, above and beyond the influences of physical activity and social interactions. Study 2 explored the effects of being outdoors on vitality through an experimental design contrasting indoor and outdoor walks. In Study 3, participants were exposed to photographic scenes of either nature or buildings. Results showed that only the nature scenes enhanced subjective vitality. Studies 4 and 5 used a diary methodology to examine within-person variations in subjective energy as a function of being outdoors, again controlling for physical and social activity. Being outdoors was associated with greater vitality, a relation that was mediated by the presence of natural elements. Limitations of these studies are discussed, as well as their implications for research on energy and vitalization.

> "Climb the mountains and get their good tidings. Nature's peace will flow into you as sunshine flows into trees. The winds will blow their own freshness into you, and the storms their energy…"

In this poem, John Muir (1901, p. 56) highlights the vitalizing effects of immersing oneself in nature, stating that natural elements bestow a sense of wellness and energy. Poets and pundits often characterize the presence of nature as having uplifting and energizing effects on human experience. In the current studies, we use multiple methodologies to explore this connection between the experience of vitality and exposure to outdoor and natural environments.

1. Nature and vitality

Vitality is defined as having physical and mental energy. When vital, people experience a sense of enthusiasm, aliveness, and energy available to the self (Ryan & Deci, 2008; Ryan & Frederick, 1997). Vitality is thus associated with feelings of vigor (McNair, Lorr, & Droppleman, 1971), activated positive affect (Watson & Tellegen, 1985), and calm energy (Thayer, 1996), all constructs entailing positively toned, energized states. Vitality has been distinguished from non-activated positive states such as happiness, satisfaction, and contentment (McNair et al., 1971; Nix, Ryan, Manly, & Deci, 1999). Subjective vitality also differs from activation per se. Indeed, many forms of activation such as anger, anxiety, or arousal are either unrelated or negatively related to the experience of vitality (Ryan & Bernstein, 2004). Instead, vitality represents energy that one can harness or regulate for purposive actions (Ryan & Deci, 2008).

Although it is a phenomenal variable, subjective vitality has been empirically associated with behavioral and health outcomes. Subjective vitality has been linked with specific configurations of brain activation and positive stress response mechanisms (e.g., Barrett, Della-Maggiore, Chouinard, & Paus, 2004; Rozanski, Blumenthal, Davidson, Saab, & Kubzansky, 2005). Subjective vitality has also been directly linked with behavioral outcomes in ego-depletion paradigms, mediating changes in behavioral measures of self-control performance (e.g., Muraven, Gagné, & Rosman, 2008). Moreover, in vital states people demonstrate better coping and report greater health and wellness (e.g., Kasser & Ryan, 1999; Penninx et al., 2000; Ryan & Frederick, 1997). Evidence also suggests that it is specifically the activated forms of positive affect associated with vitality that can leave people more resilient to physical and viral stressors, and thus less vulnerable to illness (e.g., Benyamini, Idler, Leventhal, & Leventhal, 2000; Cohen, Alper, Doyle, Treanor, & Turner,

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2006; Polk, Cohen, Doyle, Skoner, & Kirschbaum, 2005). These connections between vitality and varied health and wellness outcomes make vitality an important focus of research (Ryan & Deci, 2008).

Therefore, to complement findings of restorative effects of nature, we explore the question of whether exposure to outdoors or natural environments influence experiences of vitality. A number of previous authors have suggested this connection. For example, Stilgoe (2001) suggested that the presence of nature in one's day-to-day life is essential to avoiding exhaustion and de-vitalization (see also Katcher & Beck, 1987). Tarrant (1996) showed that recollections of outdoor experiences are effective in increasing positive affect and health. Kaplan and Talbot (1983) found that participants in wilderness experiences frequently report feeling more "alive" and engaged with the world. Greenway (1995) reported that as many as 90% of participants placed in an outdoor setting report a greater experience of aliveness and energy. Also, in a study of virtual environments, exercise in virtual outdoor environments energized participants, whereas exercise in indoor settings had a relaxing affect (Plante, Cage, Clements, & Stover, 2006).

Attention restoration theory (Kaplan, 1995; Kaplan & Kaplan, 1989) suggests that natural environments are characterized by novel and diverse objects of interest that nourish and replenish attention and depleted energy. For example, in an investigation of environmental preferences van den Berg, Koole, and van der Wulp (2003) found that viewing pictures of natural versus built environments was associated with mood restoration, including lower feelings of stress and depression. Restoration research points to the potential of outdoor settings that involve natural environments (for example, trees, mountains, lakes, or other natural environments) for diminishing stress, lowering fatigue, and facilitating mood. In contrast to this restoration focus, our interest in the present studies is on enhancing subjective energy or vitality. In other words, restorative effects have often focused on positive, low energy states (such as relaxation after stress), while subjective vitality reflects positive, high-energy states.

In examining energy effects, it is important to note that outdoor contexts often involve higher social contact and physical activity. These characteristics can potentially inflate the positive outcomes of being outside, and, therefore, may represent confounds in studying the associations of outdoor or nature contexts with energy. In part, being outdoors has been proposed to be good for health and wellbeing because when outdoors, people tend to both interact more with others and get more exercise (Furnass, 1996). Many outdoor activities also involve social interactions, which can in their own right have a wealth of positive effects on individuals (e.g., Cohen, Gottlieb, & Underwood 2000; Ishii-Kuntz, 1990), including increasing their subjective vitality (Ryan & Deci, 2008). Additionally, physical exercise has been shown to positively impact both wellbeing and subjective vitality (Frederick & Ryan, 1995; Plante & Rodin, 1990; Thayer, 1996), and there is a relation between being outdoors and the level of physical activity. In pilot studies, we explored this effect by asking participants to list and then to rate what activities most vitalize them. Social and physical activities came out as especially important for vitality in both methods, whereas outdoor activities emerged only in the rating task, suggesting that people recognized their vitalizing potential. Thus in the current studies we examine the relations of outdoors and nature to vitality, controlling for the potential confounding influences of physical activity and social relatedness.

2. The present studies

Five studies assessed the vitalizing effects of being outdoors and nature exposure in actual and imagined contexts. The first two studies focused on the vitalizing effects of being outdoors, whether in nature or in non-nature contexts, while the latter three explored the direct effect of nature as well as being outdoors, and whether the presence of nature is responsible for the effects that being outdoors has. Throughout these studies, we hypothesized that outdoor settings, physical activity, and social interactions would all be associated with higher vitality, but we also expected that outdoor experience would predict vitality even when controlling for physical and social activities. Moreover, we hypothesized that being outdoors is energizing in large part because of the higher presence of nature in outdoor contexts. We, therefore, explored in later studies whether the presence of natural elements would mediate the relation between outdoors and vitality.

3. Study 1

To begin this exploration of the association of outdoor environments with subjective vitality, we developed a vignette study in which participants rated their perceived level of vitality in hypothetical situations that varied in accord with our key situational variables. Specifically, because we hypothesized that physical activity, social interaction, and outdoor experiences might all influence subjective vitality, we developed brief vignettes that together contained a complete set of combinations of these three elements (i.e., physical activity vs. no physical activity; social activity versus solitary activity; and indoor vs. outdoor setting) to examine the independent effects of each factor in its association with subjective vitality while controlling for the potential role of the other two factors. Participants were asked to imagine themselves in each situation (all participants completed 8 such vignettes) and to rate their likely experiences in each, including their subjective vitality.

3.1. Method

3.1.1. Participants

A total of 171 undergraduates participated for extra course credit. Of these, 123 (72%) were female and 48 were male (28%). The average age was 20.16 years (SD = 1.35). About two-thirds (65.9%) were Caucasian, 15% were Asian, 8.4% were Hispanic/Latino (a), 5.4% were African-American, and 5.4% identified with other ethnic categories. All measures were completed independently in small groups of one to eight.

3.1.2. Baseline measures

Both subjective vitality and subjective wellbeing were assessed at the onset of the study to account for their influence on later vitality ratings. Baseline *state vitality* was measured with the 7-item Subjective Vitality Scale (SVS; Ryan & Frederick, 1997; sample $\alpha = 0.89$). These seven items were: "I feel alive and vital"; "I have energy and spirit"; "I don't feel very energetic" (R); "I feel alert and awake"; "I look forward to each new day"; I feel energized;" and "I feel so alive I just want to burst". Responses were made on a 1 (*strongly disagree*) to 7 (*strongly agree*) scale with respect to how participants felt "right now". Baseline (state) *pleasant emotions* (e.g., happy, pleased) and *unpleasant emotions* (e.g., unhappy, frustrated) were measured with Diener and Emmons' (1984) 9-item hedonic valence scale; responses were made on a 1 (*not at all*) to 7 (*extremely*) scale. An affect balance score was computed by subtracting the unpleasant emotion (sample $\alpha = 0.84$) from the pleasant emotion (sample $\alpha = 0.86$) scores after each had been centered at zero. Baseline (state) *satisfaction* was measured with a single item (*satisfied*) using the same 1–7 scale. Affective state and life satisfaction are generally considered to be components of subjective wellbeing (SWB; Diener & Emmons, 1984). Affect balance and life

satisfaction were highly correlated in this sample ($r = 0.64$, $p < 0.0001$); thus, an overall SWB score for each person was calculated from the mean of the affect balance and life satisfaction scores for further analyses (cf., Sheldon, Ryan, Deci, & Kasser, 2004; sample $\alpha = 0.78$).

3.1.3. Vignette measures

A total of 64 vignettes were created to include all possible combinations of three contextual variables: setting (indoor, outdoor), social interaction (with other(s), alone), and physical activity (active, sedentary). A sample vignette was, "You and a friend are walking briskly together along a long hallway in a modern building" (indoors, social, active). For comparison, another randomly assigned vignette was, "You and a couple of friends are at a local park, exercising together on the grass" (outdoors, social, active). The vignettes were split into eight different packets, each of which included all possible combinations of the three contextual factors with minimum redundancy of vignette content.

Each participant received one randomly assigned packet of eight vignettes. They were instructed that "*as you read each [vignette], please take a little time to imagine yourself as vividly as you can in the situation described. Even if you have never experienced the situation before, try to imagine yourself in it.*" They were then instructed to rate their experiences with the following prompt: "*As you visualize yourself in this situation, rate how much you feel…*" Participants rated their anticipated level of vitality, along with a number of filler items. Vitality was measured with four items (*alive and vital; energy and spirit; alert and awake*; and *energized*; sample $\alpha = 0.90$). All responses were made on a 1 (*not at all true*) to 7 (*very true*) scale. The order of the vitality and filler items was randomized in each vignette to reduce the risk of response sets with repeated ratings.

3.1.4. Statistical analyses

A multilevel random coefficient modeling approach was used (MRCM; e.g., Bryk & Raudenbush, 1992). This approach is well suited to hierarchically nested data structures such the present one, in which a lower-level unit of analysis (level 1; repeated, within-person vignette responses) is nested within a higher level of analysis (level 2; between-person baseline measures). The MIXED procedure in SAS (statistical analysis software) was used to estimate models testing the three main effects and two-way and three-way interactive effects of the vignette contextual factors on vitality ratings. Where preliminary models showed that demographic or baseline state (SVS vitality, SWB) factors were significant main effect predictors of vignette vitality, these were retained in the main analyses reported. To enhance interpretability of the model intercept parameters (Bryk & Raudenbush, 1992; Schwartz & Stone, 1998), the predictor variables were pre-treated; between-person baseline state variables were centered around their sample means. Demographic and contextual vignette variables that did not include a meaningful zero value in the original scaling were re-scaled to include zero.

3.2. Results

Table 1 shows descriptive statistics on the baseline vitality and SWB measures as well as vitality ratings according to each vignette contextual factor. Unconditional MRCM analyses of the vignette-based vitality ratings established that there was significant between-persons variation (interindividual differences) and within-persons variation (vignette differences) in these ratings (both $ps < 0.0001$). This providing a meaningful basis to examine prediction of such variations. Preliminary MRCM analyses showed that age, sex, and race/ethnicity were not predictors of vitality ratings (all $ps > 0.05$), so these variables will not be further considered. Both baseline state variables were related to the vignette ratings of vitality in preliminary models: SVS state vitality and state SWB. These variables were retained for further analyses.

Table 1
Descriptive statistics on baseline measures and vitality ratings by vignette contextual factor (Study 1).

Variable	*M*	SD	Range
Baseline measures			
Vitality	4.22	1.20	1.29–7.00
SWB	2.73	1.69	−2.08–6.00
Vitality ratings by vignette factor			
Outdoor	5.03	1.40	1.00–7.00
Indoors	4.66	1.48	1.00–7.00
With others	5.10	1.34	1.00–7.00
Alone	4.59	1.52	1.00–7.00
Physically active	5.39	1.32	1.00–7.00
Sedentary	4.30	1.37	1.00–7.00

Note. $N = 171$. SWB = subjective wellbeing.

The results of the full MRCM analysis are shown in Table 2. Baseline vitality predicted higher vignette vitality ($p < 0.0001$), whereas baseline SWB did not ($p > 0.37$). Most importantly, all three contextual variables had main effects on situational vitality, such that people reported higher levels of vitality when outside, when with others, and when physically active (all $ps < 0.0001$). There was also a two-way interaction between physical activity and social interaction ($p < 0.0001$), such that in 'active' vignettes, participants reported similarly high levels of vitality when with others ($M = 5.50$, SD = 1.29) and when alone ($M = 5.28$, SD = 1.35), although a paired *t*-test showed that this difference was significant, $t(170) = 2.58$, $p < 0.01$. In 'sedentary' vignettes, subjects reported considerably higher vitality when socializing ($M = 4.69$, SD = 1.26) than when alone ($M = 3.91$, SD = 1.36), paired $t(170) = 8.99$, $p < 0.0001$. No other significant interactions were found.

3.3. Brief discussion

This vignette study provided initial support for the role of outdoor experience on vitality, and in particular showed that outdoor experience itself related to vitality, apart from the social and physical activities with which outdoor experiences may be associated. This study found that stimulus materials that involved social and physical activities were vitality enhancing, and indeed, vignettes in which one was alone and inactive were associated with comparatively low levels of reported vitality. The effect of outdoor experience was

Table 2
Multilevel model prediction of vitality ratings from baseline psychological measures and vignette factors (Study 1).

Predictor	Vitality	
	Estimate	*t* value
Baseline vitality	0.25	4.37*
Baseline SWB	0.04	0.90
Setting	0.19	6.27*
Social	0.25	8.40*
Activity	0.54	17.98*
Setting × social	0.00	0.01
Setting × activity	−0.04	−1.45
Social × activity	−0.14	−4.68*
Setting × social × activity	0.04	1.28

Note. $N = 171$. Parameter estimates are unstandardized. SWB = subjective well-being. Setting = outdoors vs. indoors; social = with other(s) vs. alone; activity = active vs. sedentary.
*$p < 0.0001$.

unconditional, however, in that it was seen as vitalizing regardless of the social or physical activity circumstances in the vignettes.

4. Study 2

Study 1 focused on the association of vitality with outdoor environments. Study 2 was designed to compare the vitalizing effect of actually being in an outdoor environment versus in an indoor environment. Specifically, using an experimental design, participants were randomly assigned to a walk in one of two environments, and ratings of current vitality were collected before and after the experience. Because the evidence from Study 1 suggested that physical and social activities are vitalizing, Study 2 controlled for these two factors while examining the impact of an outdoor nature experience on vitality.

4.1. Participants

Eighty undergraduates (66 women and 14 men) participated for extra course credit. Ages of participants ranged from 18 to 22 years ($M = 20$ years).

4.2. Procedure

Data collection took place during the months of September and October between 11am and 4pm when weather conditions permitted. Participants were randomly assigned to either an indoor or outdoor condition. First, they completed the Subjective Vitality scale. Next, an experimenter (one experimenter led all participants) guided participants on a short walk for 15 min; both outdoor and indoor walks were the same length. During this time, experimenters explained that they would engage in a silent walk together with the participant during which they could focus on or think about whatever they wished. If assigned to the indoor condition, participants were led through a series of underground hallways and tunnels that were devoid of living things, although there were many objects, posters, physical changes, and colors present. Participants in the outdoor condition walked on a largely tree-lined footpath along a river that runs parallel to the university campus. Experimenters were instructed to walk at the same speed in both conditions. A second questionnaire packet assessed vitality immediately after the walk in either location.

4.3. Materials

4.3.1. Subjective vitality

In addition to filler scales administered to prevent awareness of the study's focus, participants completed the 7-item Subjective Vitality scale (Ryan & Frederick, 1997) described in study 1 using a scale of 1(*not at all true*) *to* 7(*very true*). Cronbach alphas for the SVS (baseline, time 2) were 0.89 and 0.92, respectively.

4.4. Results

Preliminary analyses showed no sex differences, or differences as a function of a coding for sunny versus cloudy weather conditions, $ps > 0.05$. Therefore, these were not included in the main analysis.

A repeated measures analysis of variance (ANOVA) tested the interaction of within subject vitality (before and after intervention) with the between subjects intervention. Therefore, in this analysis, the between subjects factor was condition (indoor vs. outdoor), the within subjects factor was time (before and after the manipulation), and the outcome variable was subjective vitality. The interaction effect, $F(1, 77) = 6.65$, $p < 0.05$, is shown in Fig. 1. Simple effects showed that indoor walk participants experienced no change in vitality over time, $F(1, 39) = 1.29$, $p > 0.25$ (M before $= 3.8$, M after $= 2.3$), whereas those walking the natural path experienced an increase in vitality ($M = 3.9$) to after ($M = 5.4$), $F(1, 39) = 15.12$, $p < 0.01$.

4.5. Brief discussion

Study 2 provided experimental evidence for the vitalizing effect of being in an outdoor setting. That is, individuals walking outdoors reported a greater change in vitality compared with indoor walkers, controlling for social and physical activity. This study thus provides further support for the direct effect of outdoor environments on vitality. However, Study 2 tested the indoor versus outdoor effect through only one setting contrast–the river walk versus the tunnel walk. Study 3 was designed to generalize the results of this study.

5. Study 3

In Study 3, we sought to provide another experimental test of the potential vitalizing effect of natural environments using a set of photographic images depicting either natural outdoor settings or scenes of constructed or built environments (i.e. buildings). Photographic stimuli have been used in a number of past studies contrasting natural versus built environmental preferences (e.g. Galindo & Rodriguez, 2000; Herzog, Black, Fountaine, & Knotts, 1997; Kaplan & Kaplan, 1995; Ulrich, 1981). These studies presented either natural or urban slides to examine effects on attention, interest, positive mood, and benefits to health, but here our focus was specifically on the vitalizing effects of each type of exposure. Vitality was assessed before and after participants were asked to imagine themselves in the different settings depicted.

5.1. Participants

Ninety-seven undergraduates (70 women and 27 men) participated for extra course credit. Ages ranged from 19 to 22 years ($M = 20$ years).

5.2. Procedure

Participants were randomly assigned to either a nature or non-nature condition. First, they completed the Subjective Vitality scale.

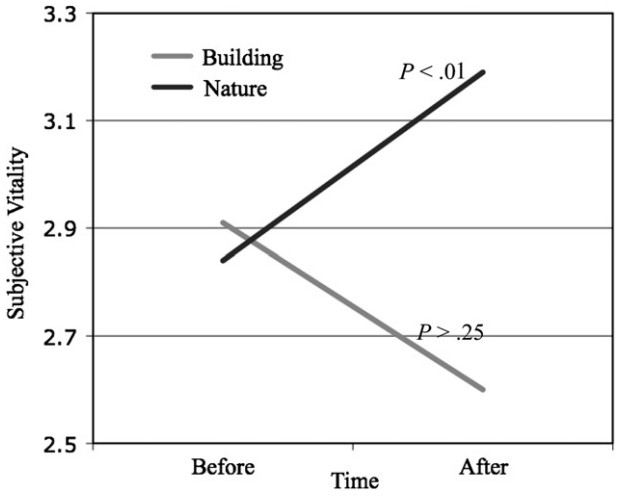

Fig. 1. Study 2 interacting effects of indoor–outdoor intervention predicting vitality over time.

Second, participants were exposed to a set of four slides, appearing for 2 min each, which depicted images of either scenes of building exteriors or of natural outdoor scenes. While viewing slides, participants listened to a recorded script designed to orient them to the experience. Before leaving, participants completed the Subjective Vitality scale for a second time.

5.3. Materials

Participants completed the *Subjective Vitality scale* used in the previous study (Cronbach's alpha was 0.76 at time 1 and 0.74 at time 2). Additionally, we showed eight slides depicting either nature (four slides; for example, depicting a desert with surrounding cliff edges, and a night lake scene) or non-nature (four slides; for example, depicting a city street with buildings on either side, and a night road scene) scenes. Slides were selected when they depicted scenes of entirely man-made environments, or entirely nature environments; matched an opposite-condition slide, were high in quality and clear, and did not depict affectively-imbued content, such as academic contexts, specific types of identifiable buildings (such as firehouses, restaurants, etc), or animals. Slides were shown to one participant per session for a period of 2 min each on a 19-in screen, and were coupled with a script typically used in imagery exercises. This script (lasting 2 min) encouraged participants to attend to their environments, to notice colors and textures, and to imagine sounds and smells. The same script was used for both conditions, and building and nature slides were loosely matched on color, complexity, layout, and brightness, based on judgments by a group of eight students naïve of condition or the nature of the study. This presentation was utilized to allow participants an opportunity to immerse themselves in the environment.

5.4. Results

Preliminary analyses showed no sex differences in vitality. A repeated measures analysis of variance (ANOVA) was conducted to assess the effects of nature intervention on change in vitality. Therefore, as in Study 2, the between subjects factor was condition (in this case, nature vs. non-nature), the within subjects factor was time (before and after the manipulation), and the outcome variable was subjective vitality. The significant interaction ($F(1, 96) = 13.81$, $p < 0.01$) between vitality over time and the manipulation is shown in Fig. 2. Simple effects showed that participants in the nature condition reported an increase in vitality over time, $F(1, 44) = 4.29$, $p < 0.05$ (M before $= 2.8$, M after $= 3.2$); whereas those who viewed building slides experienced a decrease in vitality ($M = 2.9$) to after ($M = 2.6$), $F(1, 52) = 20.20$, $p < 0.01$.

5.5. Brief discussion

Study 3 provided further experimental support for the potential vitalizing effects of natural environments. Specifically, participants who were exposed to nature images experienced an increase in subjective vitality, whereas participants who were exposed to scenes of buildings experienced a drop in vitality. van den Berg et al. (2003) had found that viewing films of natural scenes was more *restorative* (positive mood enhancing) than was viewing films of built environments. We did not measure restorative variables here, but rather found a parallel effect for vitality.

In Study 3, we employed various natural and artificial scenes, but they were also ones selected by the experimenter. In addition, Study 3 participants had to imagine themselves within these scenes, rather than directly experiencing outdoor nature. Thus, in Study 4 we harness another methodology—an *experience-sampling* procedure, to capture a range of indoor and outdoor settings as they

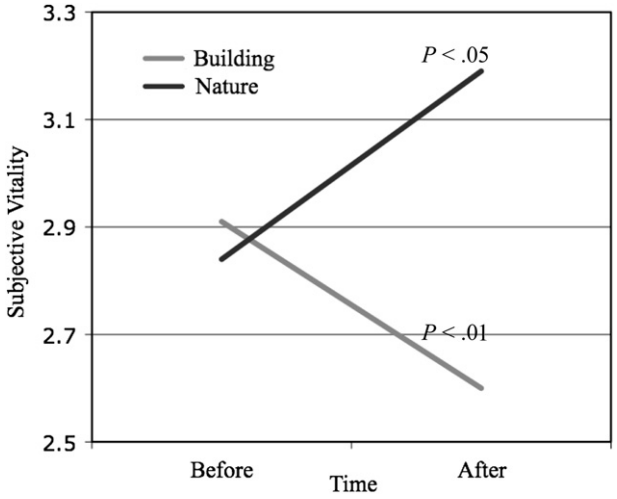

Fig. 2. Study 3 interacting effects of nature or building slide intervention predicting vitality over time.

are encountered in everyday life and their associations with subjective energy. In addition, in this study we also attempt to track the degree to which settings, either indoor or outdoor, contained natural elements that relate to the vitalizing effect.

6. Study 4

Participants completed a 14-day diary study, involving both bedtime and experience-sampling components. The entire sample completed a daily "day-end report," which asked about outdoor, nature, social, and physical activities experienced over the day. In addition, approximately one-half of all participants who completed the bedtime portion of the study also engaged in the experience-sampling procedure, This portion of the involved responding to pages received at random points during each day by reporting on current activities, including where the activities occurred (specifically, whether they were indoor or outdoor, and how much nature was present when they occurred). The diary methods focused on assessing nature exposure as well as outdoor experiences, to begin to disentangle natural from other outdoor environments (e.g., building areas, parking lots).

6.1. Participants

Participants were 138 students (41 men and 97 women) ages 18–24 ($M = 20$ years); 5% were Black, 4% Hispanic, 15% Pacific Islander or Asian, and 73% Caucasian.

6.1.1. Trait subjective vitality

Participants completed trait version of the seven-item Subjective Vitality scale used in Study 2 (present study $\alpha = 0.86$). Test–retest reliabilities for the trait-level measure were 0.64 over an eight-week period (Ryan & Frederick, 1997).

The following measures were collected from participants on the evenings of each of the fourteen study days and reflect general experiences throughout the day.

6.1.2. Daily subjective vitality

A brief state subjective vitality scale consisting of three of the seven items from the longer (Ryan & Frederick, 1997) scale assessed daily vitality in the diary logs. Items specified for participants to respond based on how they were feeling "right now." These items reliably represented the vitality construct ($\alpha = 0.86$).

6.1.3. Daily time outside

Participants responded *yes* (61% of days) or *no* (39% of days) to the item: "During the day, I spent more than 20 min outside."

6.1.4. Daily exercise

Exercise was assessed with the single item: "During the day, I exercised for 20 or more minutes." Participants responded *yes* or *no* to this item (no = 65%; yes = 25%).

6.1.5. Daily social interaction

To assess social interaction, we used a single item: "During the day, I spent more than 20 min of social interaction," participants responded either *yes* (73%) or *no* (17%).

6.2. Procedures

Participants attended an initial study session in which they completed trait vitality and personality questionnaires. Instructions, pagers, and paper questionnaires for the diary portion of the study were provided at this time. Participants were told that they might forfeit partial credit if they do not complete a significant portion of the study, but all participants received full credit. At each page, participants completed either an "activities" survey asking about their daily activities or a "relationships" survey asking about their interpersonal interactions. Only participants completing the "activities" diary survey (one-half of the total participants) will be included in analyses pertaining to these data. These participants were paged three times a day at random intervals within 4-h blocks of time over a 14-day span (for a total of 42 pages). Each time they were paged, they reported characteristics about the activities they were engaged in and whether the activity took place outside, in natural versus artificial settings, involved social interactions, or involved physical activity. Participants responded 0 for *no* and 1 for *yes*.

Each evening before going to sleep, all participants completed a day-end or bedtime survey that asked participants to report on outdoors, social, or physical activities throughout the day, as well as their daily vitality.

6.3. Results

6.3.1. Preliminary analyses

Because the categories of nature, outdoors, physical, and social activities are not exclusive, we first examined the degree to which these categories were correlated for both experience and day-end data (see Table 3). Results of chi-square tests showed that the four predictors were interrelated. The strongest relation was between being outside and in nature, $\chi^2 = 483.2$, $p < 0.01$ and $\chi^2 = 102.5$, $p < 0.01$, for experience-sampling and end of day, respectively. The only non-significant relation was between social activity and being outdoors in the experience-sampling portion of the study, $\chi^2 = 0.4$, $p < 0.10$. Table 4 summarizes Pearson correlations for the four predictors and subjective vitality. Each of the four predictors related to subjective vitality in the present study.

6.3.2. Overview of primary analyses

Hierarchical linear modeling (HLM) was used due to the nested nature of the diary data within individuals (Bryk & Raudenbush, 1992). Using HLM, the interdependence of person-nested daily data is accounted for and individual differences can be assessed while simultaneously measuring daily relations. HLM is also better able to work with missing data than ordinary least squares regression (Little & Rubin, 1987). Day-end and experience-sampling data were analyzed in two separate models. In each model, lower-level (level 1) units were daily reports (either day-end or experience reports); while high-level (level 2) units reflected between-person differences. For both experience and day-end vitality, an unconditional model was first run to assess the amount of variability that occurred between and within individuals (i.e. the Intra-Class Correlation or ICC). A second model predicted experience and daily vitality from level 1 and level 2 predictors. HLM models controlled for previous day's wellbeing because the validity of daily reports is susceptible to be compromised by autocorrelations in the data (Egloff, Tausch, Kohlmann, & Krohne, 1995; Marco & Suls, 1993; Reis, Sheldon, Gable, Roscoe, & Ryan, 2000).

Table 3
Study 4 chi-square analyses between nature, being outside, physical and social activity.

	Experiences			End of day	
	Outside	Nature	Physical	Outside	Physical
Nature	483.3 (0.42)				
Physical	245.0 (0.31)	221.0 (0.28)		102.5 (0.24)	
Social	0.4ns	7.1 (0.06)	9.9 (0.07)	24.5 (0.12)	13.0 (0.09)

Note: contingency coefficients presented in parentheses.
All chi-square coefficients were $p < 0.01$ unless otherwise stated.
Experience $n = 2310$; day $n = 1664$.

For the day-end data, vitality throughout the day was predicted from being outside, physical activity, social activity, and a dichotomous weekend (1; Saturday and Sunday) vs. weekday (0; Monday to Friday). The resulting day-end model was: $\text{vitality}_{ij} = \beta_{0j} + \beta_{1j}$ (outdoor) $+ \beta_{2j}$ (physical) $+ \beta_{3j}$ (social) $+ \beta_{4j}$ (yesterday's vitality) $+ \beta_{5j}$ (weekend vs. weekday) $+ r_{ij}$. We controlled for sex and baseline vitality by including them in the level 2 model. Equation for level 2 were as follows: $\beta_{0-4j} = \gamma_{00} + \gamma_{0-41}$ (baseline vitality) $+ \gamma_{0-42}$ (sex). See Table 5 for results.

The experience-sampling model for the participants who were also receiving pages was similar to that for the day-end data, but included the *presence of nature* as an additional level 1 predictor. The level 1 model was: $\text{vitality}_{ij} = \beta_{0j} + \beta_{1j}$ (outdoor) $+ \beta_{2j}$ (nature) $+ \beta_{3j}$ (physical) $+ \beta_{4j}$ (social) $+ \beta_{5j}$ (previously reported vitality) $+ \beta_{6j}$ (weekend vs. weekday) $+ r_{ij}$. See Table 6 for results.

6.3.3. Day-end

The ICC indicated that 39% of the variability in daily vitality occurred between individuals and 61% within individuals. Results of full hierarchical model showed that, at the second level (person-level), participant sex did not predict vitality ($b = 1.56$), $t(111) = 0.85$, $p < 0.10$, and those who had higher baseline vitality were more likely to have vitality across days ($b = 4.04$), $t(111) = 5.34$, $p < 0.01$. At level 1 (day-level), higher daily vitality was predicted by day of the week, ($b = 3.17$) $t(111) = 3.29$, $p < 0.01$, more than 20 min of exercise ($b = 2.38$), $t(111) = 2.62$, $p < 0.01$, more than 20 min social interaction ($b = 6.22$) $t(111) = 5.12$, $p < 0.01$, and past day's vitality ($b = 0.99$), $t(111) = 3.15$, $p < 0.01$. Even when controlling for all of these factors, on days in which participants spent more than 20 min outdoors, they also experienced greater vitality ($b = 1.84$),

Table 4
Studies 4 and 5 correlations between activity characteristics (physical and social activity, outdoors, nature) and subjective vitality.

	Study 4	Study 4	Study 5
	Experience vitality	Day-end vitality	Vitality
Physical Activity	0.16**	0.08**	0.32**
Social activity	0.32**	0.24**	0.17**
Outdoors	0.12**	0.12**	0.17**
Nature	0.11**	–	0.30**

Note: Study 4 experience $n = 2310$; Study 4 day-end $n = 1664$; Study 5$ns = 1118–1162$.
**$p < 0.01$.

Table 5
Studies 4 and 5 HLM models – t statistic predicting subjective vitality.

Level 1	Subjective vitality		
	Study 4 day-end t	Study 4 experience t	Study 5 t
ICC	0.39	0.58	0.18
Vitality-1	3.15**	15.34**	16.25**
Physical activity	2.62**	5.56**	9.59**
Social activity	5.12**	13.42**	2.51*
Outdoors	2.31*	1.89***	0.04
Nature	–	2.37*	4.69**

*$p < 0.05$; **$p < 0.01$; ***$p < 0.07$.

$t(110) = 2.31$, $p < 0.05$. Additional variance remained unaccounted for after including these predictors in the model, $\chi^2 = 274.1$, $p < 0.01$.

6.3.4. Experience sampling

The ICC indicated that 58% of the variability in activity specific vitality occurred between individuals and 42% within individuals. Person-level analyses showed that women reported a trend toward higher vitality, ($b = 0.29$), $t(59) = 1.75$, $p < 0.09$, and those that reported higher baseline vitality also had higher vitality across days, ($b = 3.92$), $t(59) = 4.94$, $p < 0.01$. Within individuals, previously reported vitality predicted current vitality, ($b = 0.90$), $t(59) = 15.34$, $p < 0.01$, weekends predicted higher vitality, ($b = 2.85$) $t(111) = 3.01$, $p < 0.01$, activities that required physical exercise predicted greater vitality ($b = 0.65$), $t(59) = 5.56$, $p < 0.01$, and social interaction ($b = 0.95$), $t(59) = 13.42$, $p < 0.01$. Activities that involved spending time outside marginally related to increased vitality ($b = 0.25$), $t(59) = 1.79$, $p < 0.08$. Results showed that when controlling for physical, social, and outdoor activity, the behaviors that took place in nature predicted a greater experience of vitality ($b = 0.58$), $t(59) = 2.37$, $p < 0.05$. Additional variance remained unaccounted for after including these predictors in the model, $\chi^2 = 252.7$, $p < 0.01$.

6.3.5. Mediation

Mediation analyses were conducted with a series of three models as recommended by procedures outlined by Kenny, Korchmaros, and Bolger (2003) for lower-level mediations in HLM and Baron and Kenny (1986). We controlled for sex and baseline vitality, by including them in the level 2 model. Equation for level 2 were as follows: $\beta_{0-4j} = \gamma_{00} + \gamma_{0-41}$ (baseline vitality) $+ \gamma_{0-42}$ (sex). We first tested the effect of being outdoors on subjective vitality, controlling for physical and social activity and previously reported vitality, but not controlling for nature. The resulting model was: vitality$_{ij} = \beta_{0j} + \beta_{1j}$(outdoor) $+ \beta_{2j}$(physical) $+ \beta_{3j}$(social) $+ \beta_{4j}$(previous vitality) $+ r_{ij}$. Second, we predicted the mediator, the presence of nature, from outdoor exposure: nature$_{ij} = \beta_{0j} + \beta_{1j}$ (outdoor) $+ \beta_{2j}$ (physical) $+ \beta_{3j}$ (social) $+ \beta_{4j}$ (previous nature) $+ r_{ij}$. Finally, we returned to the model presented above, which predicted vitality from both nature and being outdoors. Results demonstrated that when nature was not included in the model, being outdoors predicted higher vitality, $b = 0.57$, $t(60) = 3.15$, $p < 0.01$. Furthermore, being outdoors predicted greater exposure to nature, $b = 0.92$, $t(60) = 5.92$, $p < 0.01$. As presented above, nature predicted subjective vitality $b = 0.51$, $t(59) = 2.24$, $p < 0.05$, and the effects of being outdoors dropped substantially when including nature in the model, ($b = 0.25$), $t(59) = 1.89$, $p < 0.07$. More variance was present in the unmediated model, $\chi^2 = 302.1$, $p < 0.01$. Sobel's (1982) test for indirect effect was $z = 2.10$, $p > 0.05$.

Table 6
Study 5 correlations between nature, being outside, physical and social activity.

	Experiences		
	Outside	Nature	Physical
Nature	0.38*		
Physical	−0.03	0.03	
Social	0.05	0.19*	0.10*

Note: $ns = 1118–1162$.
* $p < 0.01$.

6.4. Brief discussion

In Study 4, we used a diary method to extend previous findings showing that, at a within-person level of analysis, individuals felt more energized when outdoors. Day-end results indicated that on days in which a meaningful portion of time (at least 20 min) was spent outdoors, individuals experienced a greater sense of vitality for that day. Experience-sampling results showed that when individuals were located outdoors they reported marginally more vitality than when indoors, even when controlling for social and physical activities. The present study also demonstrated that the presence of nature had an independent energizing effect above that of being outdoors. Moreover, nature partially mediated the effects of outdoors on vitality; in other words, being outdoors was vitalizing in large part because of the presence of nature.

7. Study 5

In Study 5, we sought to replicate the within-person patterns of association between outdoor settings and vitality identified in Study 4 while further investigating the role of natural elements in mediating this pattern. Using a more intensive (6× daily) experience-sampling approach, we asked participants to report both on whether they were inside or outside, and on the amount of natural and artificial elements surrounding them. This allowed us to test again for the potential mediating effects of natural elements on the relation between indoor versus outdoor settings and vitality.

7.1. Participants

Fifty-one students (43 female and 8 male) participated. Ages ranged from 18 to 26 years; most (84.3%) lived on campus. The majority (82.4%) were Caucasian, 7.8% Asian American, 3.9% African-American, and 3.9% Hispanic.

7.2. Procedure

Participants attended an initial meeting with the experimenter in groups of 1–6; these meetings were held on Wednesday evenings and the four-day experience-sampling period began immediately on the ensuing Thursday through Sunday, and debriefing occurred on the following Monday.

At the initial meeting, participants completed surveys assessing person-level vitality and were provided with electronic pagers and diary forms, along with instructions how to complete these forms. On each of the following 4 days, participants were paged six times between the hours of 10 a.m. and 10 p.m. Each page was sent randomly within each 2-h block of time, and signaled to participants that they must complete a diary questionnaire provided to them (i.e., a signal-contingent form; see Wheeler & Reis, 1991). Participants were instructed to respond to the questionnaire immediately upon receiving page, or if unable to immediately respond, to respond as soon as was possible. Diary questionnaires were also kept very brief to maximize compliance, and asked about surroundings of the participant as well as their subjectivity energy.

7.3. Person-level measures

7.3.1. Trait subjective vitality

Four items from the full Subjective Vitality Scale (SVS; Ryan & Frederick, 1997) were used to measure trait-level energy and aliveness over the last month on a 7-point Likert-type scale. Reliability for the four-item version was 0.86.

7.4. Experience-level measures

Participants were asked to answer in terms of their "current experiences" defined by activity and their location.

7.4.1. Presence of others

For each experience, we assessed the presence of others with the single open-ended item: "how many people have you interacted with during this experience?" Participants reported interacting with an average of 1.42 people (SD = 2.82). In 40% of activities, they did not interact with anyone.

7.4.2. Physical activity

We measured physical activity with the item: "rate your average physical activity level during this experience" from 1 (low: *sitting*) *to* 5 (heavy: *running*) ($M = 1.64$; SD = 0.96).

7.4.3. Outdoors

Participants were asked whether the experience took place indoors or outdoors. Indoors experiences included being inside buildings as well as travel inside vehicles. Outdoor experiences included all those that took place outdoors, with varying degrees of nature presence. One hundred and seven experiences took place outdoors, 1063 took place indoors (seven reports had missing data).

7.4.4. Nature experience measures

Participants also indicated the presence in their current environment of natural (tree, plant, flower, window, water, grass, hill) and non-natural (building, table, TV, computer, plane, desk, book, car, pavement) 16 elements from a list provided. We selected the items reflecting natural elements based on findings regarding what people find most important about natural environments (Kaplan & Kaplan, 1995), as well as items we added ourselves. Non-natural items were generated by thinking about the artifacts and non-natural objects that would be common in students' environments. A score of +1 was given to each natural element indicated and a score of −1 was assigned to each non-natural element. Scores were independent of whether the element was indoors or outdoors. For example, a +1 was assigned to a window or plant indoors or a flower or grass outdoors. A score of −1 was assigned to a TV or desk indoors or a building or pavement outdoors.

7.4.5. State vitality

Using the SVS described above (Ryan & Frederick, 1997), participants answered the four questions according to how they feel "in the present moment." Internal consistency was $\alpha = 0.91$ for the four items.

8. Results

8.1. Preliminary analyses and overview

One thousand one hundred and seventy-seven experiences were recorded for 51 participants ($M = 23.1$). Correlations between the four predictors were lower than in Study 3. In this study, outdoor and social activities did not correlate, $r = -03$, $p > 0.05$, nor did physical exercise correlate with being outdoors or nature $r = 0.03$ and −0.05, both $ps > 0.05$. As in Study 3, outdoors activities moderately correlated with the presence of nature, $r = 0.38$, $p < 0.01$ (See Table 6).

Hierarchical linear modeling was used as in Study 4, including the same specifications. As in Study 4, we controlled for weekend (1; Saturday and Sunday) vs. weekday (0; Monday to Friday). The present study controlled for (level 2) participant sex and trait vitality. Results for both are presented in Table 4. The level 2 model was, therefore, $\beta_{0\text{–}4j} = \gamma_{00} + \gamma_{0\text{–}41}$ ((trait vitality) + $\gamma_{0\text{–}42}$ sex). The level 1 model was: vitality$_{ij} = \beta_{0j} + \beta_{1j}$ (outdoor) + β_{2j} (nature) + β_{3j} (physical) + β_{4j} (social) + β_{5j} (previous vitality) + β_{5j} (week-end vs. weekday) + r_{ij}.

8.2. Subjective vitality

The intra-class correlation indicated that 18% of the variance in vitality lay between individuals while 82% lay within. Results of full hierarchical model showed that, at level 2, participant sex did not predict vitality, ($b = -0.38$), $t(48) = -1.44$, $p > 0.10$; those who reported higher baseline vitality also reported higher daily vitality, ($b = 0.29$), $t(48) = 2.88$, $p < 0.01$. At level 1, the previous report's vitality predicted current vitality ($b = 0.91$), $t(1145) = 16.25$, $p < 0.01$, more exercise predicted higher subjective vitality ($b = 0.42$), $t(1145) = 9.59$, $p < 0.01$, as did the number of people with which the individual interacted ($b = 0.07$), $t(1145) = 2.51$, $p < 0.05$, and the presence of weekends ($b = 1.71$), $t(1145) = 4.31$, $p < 0.01$. When controlling for all other predictors, being outdoors did not predict greater vitality ($b = 0.07$), $t(1145) = 0.04$, $p > 0.05$. However, individuals were significantly more vitalized as they were exposed to more nature ($b = 0.11$), $t(1145) = 4.69$, $p < 0.01$. Additional variance remained unaccounted for, $\chi^2 = 293.0$, $p < 0.01$. The present results were designed to demonstrate an effect of nature above and beyond being outdoors; however, in this model the effect of being outdoors may have been influenced by including nature as a concurrent predictor. Therefore, we test mediation analyses to explore whether being outdoors would have a direct effect on vitality without the inclusion of nature, and whether nature mediated this effect.

8.3. Mediation

Mediation analyses were conducted with a series of three models as recommended by procedures outlined by Kenny et al. (2003) and as described in detail in Study 4. Results demonstrated that when nature was not included in the model, being outdoors predicted higher vitality ($b = 0.34$), $t(1148) = 2.54$, $p < 0.05$. Furthermore, being outdoors predicted greater exposure to nature, ($b = 1.98$), $t(1149) = 8.48$, $p < 0.01$. As presented above, nature predicted subjective vitality ($b = 0.11$), $t(1146) = 4.69$, $p < 0.01$, but being outdoors no longer related to vitality when controlling for nature, ($b = 0.07$), $t(1146) = 0.04$, $p > 0.05$. Additional variance remained unaccounted for, $\chi^2 = 232.0$, $p < 0.01$. Sobel's (1982) test of indirect effects was $z = 4.10$, $p < 0.01$.

8.4. Brief discussion

The present study elaborated on previous measures by including a sensitive measure of physical and social activity, as well as the presence of nature when both indoors and outdoors. When including these predictors, being outdoors or indoors no longer predicted greater energy. We tested for mediation by nature for the effect of outdoor on vitality and found that nature mediated this effect.

9. Discussion

Five studies using varied strategies, including surveys, vignettes, experimental manipulations, and diary methods, explored the relations of being outdoors and in nature on the experience of vitality. Study 1 used a vignette strategy to examine people's reactions to imagined circumstances that varied in terms of social, physical and outdoor versus indoor variables. Results showed that all three variables exerted independent effects on subjective vitality, demonstrating that people expect that being outdoors will be more vitalizing than an indoor environment. In Study 2, participants were led on a 15-min walk on a tree-lined path along a river (outdoor condition) or on a 15-min walk in a set of underground tunnels. Across conditions, the length and pace of the walk, and social interactions, were controlled for. Results showed that the outdoor condition led to significantly higher vitality change scores. In Study 3, we utilized a series of images depicting either nature or building settings, demonstrating that our selected outdoor natural environments facilitated vitality relative to outdoor scenes involving buildings. Because Studies 2 and 3 involved experimenter selected settings rather than the array of outdoor experiences found in day-to-day life, in Study 4 we used a 14-day diary design to test relations between both being outdoors and the presence of nature on vitality. Experience-sampling results showed that even when controlling for physical and social activity, as well as being outdoors, the presence of nature predicted vitalization. Supplemental day-end data also extended Study 1–3 results by showing that time spent outdoors predicted higher vitality on that day. In Study 5, we again used a diary design to expand on these results by including more intensive daily sampling (6× per day), more sensitive measures of social and physical activity, and a more sensitive measure of the presence of nature. Results of this final study showed that when people engaged in activities in natural surroundings, they reported those activities to be more vitalizing. As before, social and physical activities also resulted in higher vitality. When controlling for nature, physical, and social activity, being outdoors no longer predicted vitality. This differed from the findings in Study 4, where we found that nature and outdoors predicted vitality independently of one another. This inconsistency may be due to the more sensitive nature of the measures used in Study 5. Studies 4 and 5 results also revealed mediation by nature of the effects of outdoors on vitality. Although the data showed that nature is an important reason that outdoor environments are vitalizing, other characteristics of outdoor environments, such as the presence of sunlight or fresh air, as well as a sense of extent or openness, may induce additional experiences of vitality.

These studies collectively point to the positive impact of being outdoors and around natural elements on subjective vitality, above and beyond the effects of physical activities or social interactions that can take place in natural settings. This is potentially important because subjective vitality has been implicated as an important component of wellbeing and even physical health (Plante et al., 2006; Ryan & Deci, 2008). The studies may also help to explain the preferences for nature we often see in society, as reflected in people's choices of vacation spots, their willingness to spend more for land with nature views, and in subjective ratings of various environments (Galindo & Rodriguez, 2000; Kaplan, 1995).

This set of studies on subjective vitality effects represents only a small foray into the topic of how outdoor and natural settings may impact people's wellness. We hope these studies add to the growing body of work on the determinants of subjective vitality (Ryan & Deci, 2008) and expect that it may complement other work on the positive and restorative effects of nature (e.g., van den Berg et al., 2003; Hartig, Mang, & Evans, 1991). The relations between subjective vitality and restoration may be especially interesting, as both pertain to mental and physical wellbeing and both appear to be related to outdoors and nature in particular, but they are not the same. For example, restoration is often discussed in terms of arousal/activity decreasing effects (e.g., relaxation; stress reduction), whereas vitality is related to increased energy levels. It may be interesting to explore relations between vitality and outcomes found in the restoration literature in future studies.

At the same time, there are multiple limitations that warrant consideration. First, although subjective vitality ratings have been shown to correlate with varied behavioral outcomes (Ryan & Frederick, 1997) and assessments of ego-depletion (e.g. Muraven et al., 2008), we used only the subjective ratings of vitality as the dependent variable in each of these studies. These subjective outcomes are important in their own right, but nonetheless future studies might include behavioral measures of energy and vitality. We also focused narrowly on subjective vitality, and future research might explore a wider range of associated subjective outcomes, processes and correlates. Yet another limitation is that these studies employed student samples, and overrepresented women, and it is plausible that persons drawn form other populations might show different effects. For example, it might be that both being outdoors, and being in the presence of nature, could have a different influence on both older and younger individuals, as well as those in the general population who have differently structured days from those of students. Yet another limitation is that we did little to address the wide array of elements that can constitute outdoor and/or natural environments, from natural lighting to novelty of environments, or how such specific features of these contexts might produce vitalizing effects. For example, Study 2, which entailed an experimental design, we sampled only one indoor and one outdoor environment, Future research will benefit from having broader, more representative samples, which are also likely to vary more in their exposure to and relation with outdoor and natural environments. In these ways, the current studies leave many agendas for further research.

Despite these limitations, these five methodologically varied studies revealed a consistent positive relation between being outdoors and subjective vitality. This effect appears to be independent of other significant influences on subjective vitality such as levels of physical activity or social interaction, and is at least partially mediated by the presence of natural elements in the setting. These subjective vitality effects may help to explain why people often appear to be drawn to natural settings, and why as a culture we might want to think about the importance of sustaining the natural elements that surround us and enhancing people's opportunities to access them.

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