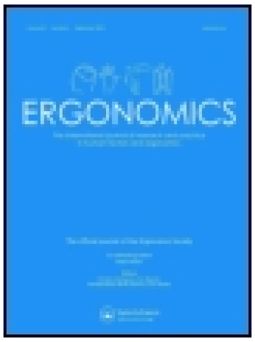

Ergonomics

ISSN: 0014-0139 (Print) 1366-5847 (Online) Journal homepage: http://www.tandfonline.com/loi/terg20

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To cite this article: Brid Sona, Erik Dietl & Anna Steidle (2018): Recovery in Sensory-Enriched Break Environments: Integrating Vision, Sound and Scent into Simulated Indoor and Outdoor Environments, Ergonomics, DOI: 10.1080/00140139.2018.1491643

To link to this article: https://doi.org/10.1080/00140139.2018.1491643

Accepted author version posted online: 02 Aug 2018.

Recovery in Sensory-Enriched Break Environments:

Integrating Vision, Sound and Scent into Simulated Indoor and Outdoor Environments

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Acknowledgments

This paper is based on research conducted by the first author in partial fulfilment of the requirements for a doctoral degree from the University of Hohenheim and supervised by the third author. We would like to acknowledge the interdisciplinary research team 'People Inside' and the chair of Business and Organizational Psychology at the University of Hohenheim for funding this project. Moreover, we want to sincerely thank our colleague Konrad Senf for proofreading parts of this manuscript! We also thank our students for their help in collecting the data.

Recovery in Sensory-Enriched Break Environments: Integrating Vision, Sound and Scent into Simulated Indoor and Outdoor Environments

Abstract

To deal with stress and exhaustion at work, personal resources need to be replenished during breaks. The aim of this laboratory study (*n* = 122 students) was to test the restorative potential of sensory-enriched break environments (SEBEs) in a between-subjects with repeated measures design, focusing on the type of the environment (natural outdoor vs. built indoor environment) and sensory input (no sensory input vs. audiovisual input vs. audiovisual and olfactory input). Analyses showed that SEBEs simulating either a natural or a lounge environment were perceived as more pleasant and restorative (fascination/being away) than a standard break room, which in turn facilitated the recovery of personal resources (mood, fatigue, arousal). Moreover, adding a congruent scent to an audiovisual simulation indirectly facilitated the recovery of personal resources via greater scent pleasantness and higher fascination and being away. The current study shows opportunities for sensory enrichment to foster restoration in break environments.

Keywords: ambient scent, restorative environments, fascination, being away, personal resources

Practitioner Summery

This project reveals the impact of the recovery process of simulated environments on personal resources. Analyses confirmed that sensory-enriched environments were

perceived as more restorative than less enriched environments, which in turn facilitated the recovery of personal resources. The results highlight the relevance of holistic sensory impressions to fostering recovery.

1. Introduction

In the face of increasing demands and stress levels at work (Hipp et al. 2016; Sonnentag, Binnewies, and Mojza 2011), humans are increasingly interested in recreation phases and the design of restorative environments (Scholz et al., 2017). Ergonomic research pointed out the positive impact of within-day work breaks for recovery (Trougakos & Hideg, 2009; Steidle, González-Morales, Hoppe, Michel, & O'Shea, 2017). For instance, Steidle et al. (2017) showed positive effects of break interventions (savouring nature vs. progressive muscle relaxation) at the workplace. Numerous researchers and studies consider natural environments as particularly effective in helping to replenish personal resources, particularly to decrease physiological stress and attentional fatigue, and to increase mood, well-being or health (e.g., Beute and de Kort 2014a, 2014b; Dahlkvist et al., 2017; Hartig et al. 2003; Ulrich et al. 1991). However, work breaks in natural environments are not always available or accessible (Richardson et al., 2016). And even when they are available or accessible, individuals may not take advantage of them (Hitchings, 2013).

Since most people in the Western world spend 80% to 90% of their time in buildings (Urlaub et al. 2010) and many employees have no opportunity to leave the building for a significant amount of time during their work breaks, organizations and employees seek restorative environments directly at the workplace and through the design of rest areas (Felsten 2009). In her review, Largo-Wight (2011) listed several recommendations on how to enhance restoration at the workplace through contact with nature, covering both outdoor (e.g., cultivating the workplace grounds for viewing or maintaining healing gardens) as well as indoor measures (e.g., lighting rooms with bright natural light or listening to recorded sounds of nature). These indoor measures build on the idea of simulating nature at work and in rest areas without access to nature, in order to fulfill the human need for 'nature-like ambient surroundings' (Kimberly, Elsbach, and Pratt 2008, 203).

To improve personal resources of employees in indoor break environments, we aim at contributing to the knowledge of how the simulation of restorative environments can create a restorative environment perception and thus facilitate the restoration of depleted resources. Past research has mainly investigated the effect of visual or auditory simulations of nature on either restorative perceptions or resource recovery. We seek to enlarge and integrate the previous findings in three ways.

First, the value of indoor environments (e.g., café, lounge) may be underestimated because most previous studies compared outdoor urban settings (usually evaluated as unrestorative) with outdoor natural settings (usually evaluated as restorative; Hartig et al. 2003; Berto et al. 2010). In contrast, we compared indoor and outdoor *sensory-enriched break environments (SEBEs)* that both might be restorative to some degree. In this context, SEBEs are standard break environments that additionally provide simulations of sensory impressions (e.g., visual or olfactory stimuli) to foster recovery effects. For instance, a windowless break room might benefit from the addition of simulated window views of nature.

Second, simulations may include different sensory impressions. Previous research on the creation of restorative environments has mainly focused on the consequences of visual and acoustic stimuli (Ulrich 1984; Laumann et al. 2003). Although studies indicate that audiovisual simulations lead to better recovery than just visual or auditory ones (Annerstedt et al. 2013; Jahncke et al. 2011), knowledge of the integrative effects of different sensory impressions is still limited. In particular, there is a lack of research on olfactory stimuli (Annerstedt et al. 2013; Dinh et al. 1999; Jahncke et al. 2011). Hence, the present study has investigated the integration of visual, acoustic, and olfactory stimuli to enhance recovery.

Third, in past research on SEBEs, studies have often focused on either restorative experience or on resource recovery as dependent variables. However, environments promote resources because they are perceived as restorative (Hartig et al., 2003). This has been tested for real natural environments, but the evidence for simulated environments is limited. Moreover, some research on scent perception indicates that the evaluation of the scent may be more relevant for its restorative effects than the scent itself (Bensafi et al. 2002). Hence, we wanted to understand how the simulation of an environment through visual, auditory, and olfactory stimuli affects restorative experience and, in turn, resource recovery among depleted persons. Doing so, we will outline the psychological pathway from specific environmental stimuli through perception to recovery (Sona, 2017[1]).

2. Background: Restorative environments

The current research builds on *Attention Restoration Theory* (*ART*; Kaplan & Kaplan, 1989) that describes how natural environments can promote recovery of depleted resources. Individuals use direct attention to concentrate on a specific task, which requires effort. In the long term, applying direct attention results in attention fatigue, characterized by concentration problems and irritability (Kaplan, 1995). In contrast, people viewing beautiful natural scenes will immediately be attracted by the fascinating stimuli and mentally distance themselves from stressful events. Thus, no direct attention is needed and depleted resources are replenished (Berman, Jonides, & Kaplan, 2008;

Kaplan & Kaplan, 1989; Kaplan & Berman, 2010). In addition, not only cognitive and physiological benefits are triggered by natural environments, but also positive effects on mood (e.g., Joye & Bolderdijk, 2015).

In line with ART, a significant body of research showed that certain natural environments support recovery, particularly reducing (attentional) fatigue and arousal, while increasing mood (Berman et. al, 2008; Beute, & de Kort, 2014a; Hartig et al., 2003; Joye & Bolderdijk, 2015; Staats, Kieviet, & Hartig, 2003; Ulrich et al., 1991). For instance, Beute and de Kort (2014a) found positive effects on mood and heart rate variability after subjects viewed pictures of nature compared to urban scenes. Moreover, Staats, Kieviet, & Hartig (2003) showed that individuals evaluated pictures of a walk through a forest more appropriate to reduce attentional fatigue compared to a walk through an urban center. Thus, even environments that mimic nature affect positive mood and better cognitive functioning (Hartig et al. 1996). Kaplan (1992) stated that the positive effects of nature are not originated by the individual’s actual presence in the environment, but rather through the simple sight of it, indicating that simulation or imagination of restorative natural environments may be equally beneficial.

ART (Kaplan 1995) describes distinct qualities for which relatively high values define restorative environments. The current research focuses on two of these qualities: 1) *soft fascination* of an environment that emphasizes effortless attention (e.g., the observation of clouds vs. hard fascination, e.g., watching a thriller); and 2) *being away*, in the form of a mental detachment from one’s usual environment. Environments which are high in these qualities support recovery and self-perceived health (Dahlkvist et al., 2016; Lindal & Hartig, 2013).

Recent research has shown that perceived fascination and being away mediates the effect of an environment on resource recovery. For instance, Dahlkvist et al.

(2016) found that the effect of greenery on self-perceived health is mediated by fascination and being away. In addition, Lindal and Hartig (2013) demonstrated that fascination and being away mediate the impact of physical attributes of built environments (entropy) on restoration likelihood. Further, a study has shown that being away mediates the effect of perceived setting interdependencies on health and well-being (von Lindern, 2017). Hence, the current research also tested perceived fascination and being away as mediators to further illuminate the psychological pathway from the restorative perception of an environment to concrete resource recovery.

2.1 Simulating restorative outdoor environments

Recovery effects seem to be more pronounced for real than for simulated nature (Kjellgren and Buhrkall 2010; Richardson et al., 2016). Previous research has investigated the impact of visual or acoustic stimuli as well as the integration of vision and audition in slideshows or simulated environments. Listening to natural sounds (e.g., water, birds) is already perceived as restorative (Alvarsson et al 2010; Ratcliffe, Gatersleben, and Sowden 2013). Similarly, merely viewing nature supports recovery (Felsten 2009; Friedman et al. 2008; Kjellgren and Buhrkall 2010). For instance, Friedman et al. (2008) installed huge plasma displays inside offices which showed a fountain area and the surroundings outside the building in real time. Seeing this nature simulation had positive effects on cognitive functioning and well-being. In the current study, we also used huge plasma displays as means for visual simulation.

Moreover, the study by Kjellgren and Buhrkall (2010) postulated that the integration of sensory impressions might enhance recovery: participants who had seen a restorative slideshow of nature reported being struck by the lack of sounds and smells. Thus, an authentic experience may well require further congruent sensory impressions, like touch, smell, and temperature (de Kort and IJsselsteijn 2006; Depledge, Stone, and Bird 2011). In this context, the terminus ‘congruency’ means that different sensory impressions match together. For instance, viewing a bird, one would expect to hear the bird singing, instead of hearing a dog barking. In line with this integrative approach, Annerstedt et al. (2013) induced physiological stress and found better restoration effects using a virtual natural environment combining a visual and congruent auditory input. Moreover, Jahncke et al. (2011) showed that depleted subjects reported more energy after watching a 7-minute movie with river sounds than listening to river sounds or noise only. Overall, audiovisual simulations of nature seem to promote recovery more strongly than visual or auditory simulations separately. Based on the previous research, we expected:

H1a: Break rooms simulating nature (visual and auditory input) are perceived as more restorative than a standard break room.

H1b: Compared to a standard break room, SEBEs (here: simulating nature) indirectly facilitate the recovery of resources (fatigue, mood and arousal). These effects are mediated by perceived fascination and being away. In particular, SEBEs strengthen the restorative experience by boosting perceived fascination of an environment and the sense of being away.

2.2 Simulating restorative indoor environments

In general, natural environments are perceived as more restorative than built environments, and outdoor environments are perceived as more restorative than indoor environments (Hartig et al. 1997). However, Gulwadi (2006) showed that in some situations of stress, individuals prefer their own homes for recovery over a natural environment: vocationally stressed individuals preferred natural environments, whereas interpersonally stressed individuals preferred home or indoor environments. These results are in line with the research showing that the favorite places of individuals are their 'home' and 'greenery' (Korpela and Hartig 1996). Similarly, the *Stress Recovery Theory* (Ulrich 1983) points out that restorative places have a low threat potential, and appear peaceful. In addition, most recovery activities (e.g., napping, relaxing, or reading for leisure) happen in informal situations, in which people can lower their guard and need not control themselves (Gulwadi 2006; Richter 2008). Hence, some indoor environments, such as lounges, cafés, or individuals' own bedrooms, which trigger associations with leisure and recovery behavior, should be perceived as particularly restorative and thus facilitate recovery. Unlike a standard break room, SEBEs simulating an indoor break environment expose participants to congruent visual and auditory impressions of the restorative indoor environment. Consequently, we expected:

H2a: Break rooms simulating an indoor environment (visual and auditory input) are perceived as more restorative than a standard break room.

H2b: Compared to a standard break room, SEBEs (here: simulating an indoor environment) indirectly facilitate the recovery of resources. These effects are mediated by perceived fascination and being away.

However, since a large part of recovery research suggests the enhanced benefits of nature (Kaplan and Kaplan 1989; Ulrich et al. 1991; Hartig et al. 2003), we assume that simulating nature may be even more effective for recovery than simulating an indoor environment. Hence, we expected:

H3a: SEBEs simulating a natural environment (visual and auditory input) are perceived as more restorative than SEBEs simulating an indoor environment (visual and auditory input).

H3b: Compared to an indoor break environment, a simulated nature environment indirectly facilitates the recovery of depleted resources. This effect is mediated by perceived fascination and being away.

2.3 Simulating congruent olfactory inputs

Previous research on SEBEs has mainly focused on visual and auditory stimuli. However, in the last decades, the use of room fragrances in airports, cinemas, hotels, train stations, banks, and retirement homes has become more popular (Knoblich, Scharf, and Schubert 2003). Baron (1990) noted that the use of pleasant ambient scents might be perceived as less obtrusive (and less expensive) than other possible methods to induce positive affect. Ambient scent may present a useful addition to audiovisual simulations of restorative environments for two reasons. First, ambient scents can elicit positive room evaluations and enhance positive affect (Baron 1983, 1986; Spangenberg, Crowley, and Henderson 1996). Second, congruent scents enhance the perceived realism or presence of an environment (Dinh et al., 1999; Tortell et al., 2007). In support, Ramic-Brkic et al. (2009) found that congruent scents compensated for quality differences of visual inputs (high vs. low quality renderings of blades of grass). Adding the congruent scent partly made up for the less authentic experience of the visual input.

Several studies indicate that an automatic evaluation of an ambient scent may be more important than the scent itself. Bensafi et al. (2002) noticed that more pleasant perceptions of a scent led to stronger decreases in the heart rates of their participants. Further, the individual liking of a scent is related to subsequent mood change (Herz 2004). Herz (2009) noted "if an individual does not like the scent of lavender she will not find it relaxing, regardless of how well and widely lavender aroma has been marketed as 'relaxing'" (p. 283). Moreover, Doucé et al. (2014) and Herrmann et al. (2013) emphasize that the match between environment and scent should be considered carefully because scents are only perceived as pleasant if they are presented in a pleasant environment and fit to the environment. In this case, a scent may support deeper immersion in a restorative environment and strengthen its restorative effects.

Overall, the pleasantness of the scent should influence the restorative perception of a simulated environment and, consequently, recovery. Thus, we expected that:

H4a: In SEBEs, congruent scents are perceived as more pleasant than neutral scents, which indirectly increases perceived fascination and being away.

H4b: Compared to neutrally scented SEBEs, congruently scented SEBEs indirectly facilitate the recovery of depleted resources. This effect is sequentially mediated via perceived scent pleasantness and via perceived fascination and being away.

3. Method

3.1 Ethics Statement

Our research project follows the ethical principles of the World Medical Association (WMA) of Helsinki. The current research does not involve critical aspects of law (e.g., medical acts), nor does it revoke anonymity of subjects. All subjects participated voluntarily, were informed about study procedure before participation, and could cancel the study at any time. The study started after verbal consent was given. In line with the Ethical Principles of the Federation of German Psychologists Associations (2016, para 7.3), there is no need to gain ethics approval if the previously mentioned aspects do not affect the research project.

3.2 Participants

German students (*n* = 131) participated in this lab study for course credit or a compensation of 20 euros. Nine subjects were excluded from further analyses due to technical problems with the artificial window (e.g., screen flicker). All participants (64 women; 58 men; mean age 22.69 years, *SD* = 2.23) had good or very good knowledge of the German language and had no allergies to the scents used. Participants were randomly assigned to one of five break environment conditions, which were counterbalanced for morning and afternoon sessions. Note that we have not balanced for gender, since this would have restricted the random assignment to quasi-randomization. However, we checked for differences between men and women regarding the examined variables, but did not find gender-specific differences.

3.3 Setting and conditions

The study was conducted in two real offices, which we used for the study, labeled ‘work room’ and ‘break room.’ Both rooms were architecturally identical, except an additional cooling system of the walls in the break room. This arrangement of settings (work room vs. break room) was designed to reduce potentially biasing effects due to differences between the work room and the break room, and facilitate recovery in all break room conditions by a spatial distance from the work setting (von Lindern, 2017). Therefore, other ambient conditions were held constant during the sessions. In line with recommendations for thermal comfort during the summer months, room temperature was set to 23 °C (de Dear and Brager 2002), air volume flow was constant in both rooms (400 m^3/h), and participants were advised to bring along different garments, so that they could adapt their clothing to feel comfortable during the study. Both rooms were lit by artificial light with no daylight. Warm white light, which has been shown to create a cozy environment (Kuijsters et al. 2015), was in the break room and neutral white light was used in the work room (for further information about the physical conditions, see supplemental materials). Additionally, the break room provided comfortable elements, including a cushioned seat, some decorations, and plants. Overall, the five break room conditions provided comparable physical comfort (see supplemental material for more details on the setting and the procedure).

The five different break room conditions varied in terms of simulated sensory input (no sensory input vs. audiovisual input vs. audiovisual and olfactory input) and in terms of the type of simulated environment (natural outdoor vs. built indoor environment). In detail, we labelled and defined the five conditions as follows: *(1) Control condition*: no window, no sound, no scent; *(2) Nature condition:* window 'nature', bird sound, neutralizing air/no scent; *(3) Lounge condition:* window 'lounge', instrumental music, neutralizing air/no scent; (4) *Scented nature condition:* window 'nature', bird sound, congruent scent*; (5) Scented lounge condition:* window 'lounge', instrumental music, congruent scent.

For the selection of the outdoor and indoor environment, we used results from a large explorative pre-study (n = 265). In this pre-study, participants described their preferred outdoor and indoor environments for recovery. For outdoor environments, frequency analyses pointed out that participants mostly preferred 'park/garden,' followed by ‘edge of the forest,’ ‘nature,’ ‘fields/meadows,’, and ‘sea/beach/lake/water.’ Thus, in the current study, we simulated a view of park scenery through an artificial window as a restorative outdoor environment (see Fig. 1).

For indoor environments, frequency analysis of the pre-study pointed out that participants mostly preferred ‘home,’ followed by ‘living room,’ ’my room,’ and ‘café.’ In the current study, participants were instructed that they were at work, performing depleting tasks and then having a break in a separate break room. Thus, we had to simulate a realistic indoor environment which could be located next to the work place and which indicated a fit to the indoor environments mentioned in the pre-study. To do this, we simulated a view of lounge scenery through an artificial interior window as an indoor environment (see Fig. 1).

3.3.1 Audiovisual simulation

Visual stimuli were presented in an artificial window, consisting of three high-resolution LED screens with speakers (Samsung LFD MD65C LED; 165 cm diagonal; 4096 x 2304 pixels [= 4 K]). Participants saw a video sequence of a park in the natural outdoor condition and a video sequence of a lounge in the built indoor condition. Movement (e.g., wind, changes in light) was visible in the screens. Note that movements were greater for the outdoor compared to the indoor environment; however, big movements would not be expected in a real indoor environment. Thus, we created realistic impressions of both indoor and outdoor environments.

The visual simulation of the two restorative environments was supported by congruent acoustic stimuli, which were chosen to support relaxation by triggering positive valence and low to moderate arousal: bird sounds in the natural outdoor condition (Ratcliffe et al., 2013), and instrumental music in the built indoor condition (Khalfa et al. 2003; see also in supplemental material: ‘Auditory Material’).

3.3.2 Olfactory simulation

In two groups, a congruent ambient scent was added to the audiovisual simulation: a scent composition of rosewood, geranium, ylang-ylang, olibanum (frankincense) and hyssop in the natural outdoor condition, and a composition of rosewood and cardamom in the built indoor condition. The two scent compositions were created by a scent expert especially for the simulated scenarios. The procedure of the scent compositions was conducted in three steps: 1) We provided the two different visual stimuli (nature vs. lounge) to the scent expert, asking for a pleasant scent that should be congruent to the visual input and that should support recovery processes. (2) The scent expert created the two scents taken into account our demands. For instance, the scent expert used ylang-ylang, since it induces the association of ‘green’, like the green grass which was presented on the artificial window view of nature. Moreover, ylang-ylang has a ‘balancing’ effect which might be helpful to induce relaxation. It reduces blood pressure and heart rate, whereas it enhances alertness and attention (Hongratanaworakit & Buchbauer, 2004). However, it is important to note that the individual substances (e. g., ylang-ylang) do not give a specific information about the perceived odor of the scent composition, since combining various odor substances elicits interactions between the different odors, resulting in novel olfactory perceptions. Hence, for individuals who are not experts in the field of odor analyses, the prediction of the olfactory impression on the basis of the used substances is rather difficult. (3) Moreover, the intensity of the respective ambient scents was tested in a pre-study (n = 12) to identify perception thresholds, since the pleasantness of a scent also depends on the intensity level (Spangenberg et al. 1996). The released ambient scent should be perceived as pleasant, but should not be too intensive. Thus, we tried to induce ambient scents above the odor detection threshold, but below odor identification. In addition, the concentration of the released scent molecules was lower than the molecules in a real park or lounge, since high scent intensities are generally perceived as unpleasant. The participants of the pre-study evaluated the used scents as pleasant.

The ambient scent was dispensed by an aroma dispenser (*Air Creative 851*). The testing room had a size of 51 m^3 (the scent diffuser used is suitable up to 80 m^3). The scent was distributed in the form of cool vapor produced by a fan. To ensure that ambient scent intensities stayed approximately constant during the whole study, the intake air, the circulating air, and the air volume flow in both rooms was predetermined (400 m^3/h). To ensure the change of ambient scent from one condition to the next, the air volume flow was increased from 400 m^3/h to 1000 m^3/h for 15 minutes between conditions. All other groups (nature condition, lounge condition, and control group) received an odor neutralizer provided by *Air Creative* (http://aircreative.com) to ensure that the air quality was neutral in all conditions (e.g., to neutralize unpleasant vapors seeping out from building materials).

3.4 Measures

3.4.1 Perception of the break room

The pleasantness of the simulated environment was assessed for each simulated sensory input. *Pleasantness of window view*, *sound,* and *odor* was assessed with one rating each (1: pleasant – 7: unpleasant). Mean item response was used as a score and higher values indicate higher pleasantness. The perception of the restorative experience of the break rooms was assessed with two shortened subscales of the *Perceived Restorativeness Scale (PRS;* Hartig et al. 1997; shortened by Berto et al., 2010), namely being away (4 items) and fascination (5 items), which are frequently used in the literature to measure the restorative potential of environments (Berto et al., 2010; Dahlkvist et al., 2016; Lindal & Hartig, 2013; von Lindern, 2017). Items were answered on a six-point Likert scale (1 = little – 6 = extremely; e.g., fascination: 'There is much to explore and discover here'; being away: 'This place gives me a break from my day-to-day routine'). All items of the two factors of PRS are highly correlated. Furthermore, the internal consistency was very high with α = .90. Thus, mean item response of all items was used as a score and higher values indicate higher restorative experience.

3.4.2 Measures of personal resources

To assess restoration effects, three personal resources were assessed: fatigue, mood, and arousal. We used subjective measurements, since further research could show significant correlations between subjective ratings and objective measurements. For instance, Belmont et al. (2009) indicated that participants with decreased attention performance showed also an increase in subjective fatigue. Thus, in the current study, subjective fatigue was used as an indicator for attentional fatigue. Participants responded three times to the resource measures: before and after the depletion phase, and during the post-restoration phase.

We measured participants' *fatigue* (three items: 'tired', 'dull', 'sleepy'), *mood* (four items: 'happy', 'amused', 'cheerful' , 'bright') and *arousal* (five items: 'nervous', 'calm', 'relaxed', 'balanced', 'easy') from *Nitsch's Personal State Scale* (1976; adapted from Apenburg 1986) using a six-point Likert scale (1 = little – 6 =

extremely). We performed confirmatory factor analyses to assess the discriminant validity of our three outcome measures. Our three-factor model (fatigue, mood, and arousal) showed acceptable fit to the observed covariance matrix at all three time points (time 1: $\chi^2(51, N = 122) = 83.38$, $p = .003$; $\chi^2/df = 1.63$, CFI = .94, TLI = .92, RMSEA = .07, SRMR =.08; time 2: $\chi^2(51, N = 122) = 107.94$, $p < .001$; $\chi^2/df = 2.12$, CFI = .94, TLI = .92, RMSEA = .10, SRMR =.07; time 3: $\chi^2(51, N = 122) = 98.31$, $p < .001$; $\chi^2/df = 1.93$, CFI = .94, TLI = .92, RMSEA = .09, SRMR =.07), with significant factor loadings for all items on intended factors. The three-factor measurement model produced a significant improvement in chi-square over more parsimonious models in which we combined the three constructs to load on a single factor (time 1: $\Delta\chi^2(3) = 167.79$, $p < .001$; time 2: $\Delta\chi^2(3) = 203.16$, $p < .001$; time 3: $\Delta\chi^2(3) = 183.01$, $p < .001$). Moreover, the scales showed good reliabilities at all three measuring points (alphas between .75 and .92). Mean item responses were used as scores and higher values indicate a higher amount of fatigue, mood or arousal.

3.5 Procedure

The lab study comprised three phases (adapted from Berto, 2005; Hartig et al., 1991; Ulrich et al., 1991): a depletion phase, a restoration phase, and a post-restoration phase.

3.5.1 Depletion phase

Participants were seated in front of a laptop in a simulated office. Then they read the cover story, explaining that they would take the place of an air traffic controller in a big company and would work on several appropriate tasks during the following 50 minutes, all of which deplete attentional and self-control resources. Afterwards, participants answered questions about their current mood, fatigue, and arousal. These measures served as baseline measures of participants' personal resources. During the subsequent depletion phase, participants worked on three cognitively demanding tasks for 50 minutes: a single n-Back task for about 15 minutes (Ragland et al. 2002), a Stroop task for about 10 minutes (Stroop 1935), and an Attention Network Task for about 25 minutes (Fan et al., 2005). The tasks were designed to consume personal resources, since directed attention is needed to perform them. The type and duration of the tasks was chosen according to previous restoration studies intending to deplete participants before a restoration phase (e.g., Berman, Jonides and Kaplan 2008). After 50 minutes, depletion effects could be expected on both affective and cognitive resources (e.g., Hartig et al. 1996; Ulrich et al. 1991). As a manipulation check, personal resources were measured again after the depleting tasks.

3.5.2 Restoration phase

After the depletion phase, experimenters asked participants to step into the adjacent room, in which one of the five break room conditions had been prepared. Participants stayed in the break room for 15 minutes. First, they answered a few demographic questions (2 min.) and were then asked to relax and open themselves to the break room environment. For 2 minutes, the laptop screen was blocked to ensure that participants perceive the environment. Then, participants answered a few questions regarding the perceived pleasantness and restorativeness of the environment (2 minutes) and again had time to perceive the environment.

3.5.3 Post-restoration phase

After the restoration phase, participants went back to their prior workplace in the simulated office and again indicated the level of their personal resources. Finally, participants assessed the environment and ambient conditions in both rooms.

3.6 Analytic Strategy

First, baseline comparisons for personal resources were performed to examine whether differences in personal resources (fatigue, arousal and mood) already existed before the experiment started (at baseline). In addition, a check of scent induction was performed to investigate whether the ambient scents fit to the presented visual stimuli and whether the unscented control group was perceived odorless. Resource depletion was examined for all three personal resources to test whether the depletion manipulation worked as intended and depleted participant's personal resources. Moreover, resource restoration was investigated by testing the effect of the different break environments on individual's perception of the environment and recovery of personal resources.

To demonstrate the proposed psychological chain of effects, simple, serial and sequential regression analysis were conducted with PROCESS (Hayes 2013), using the heteroscedasticity-consistent standard error HC3. This estimator is recommended when testing hypotheses with OLS regression (Hayes 2013; Hayes and Cai 2007). Further, as suggested by Preacher, Zyphur, and Zhang (2010), we tested all indirect effects as directed hypotheses by using a one-tailed alpha level (α = .05; 90% bias-corrected bootstrap confidence interval; hypotheses are confirmed if the confidence interval did not include zero). Serial mediations followed the logic of the proposed causal chain: environmental condition → perception of the environment → personal resources after the restoration phase (see Fig. 2). We used indicator coding for sensory enrichment (experimental conditions = 1, control group = 0), simulated environments (nature condition = 1, lounge = 0) and sensory input (scented conditions = 1, unscented conditions = 0; Hayes and Preacher 2014). Dependent variables were the restoration of personal resources from before to after the break (difference between personal resources at t3 - t2). Indicators of personal resources were fatigue, mood and arousal.

4. Results

4.1 Baseline comparisons

Table 1 provides means and standard deviations for personal resources and perception of the break room (see also Table S1 for descriptives of further variables related to the perception of the break room). An ANOVA on the subjective measures of the resources at t1 pointed out that there were no differences in participants' baseline resources between the five break room conditions. Thus, there was no need to control for t1.

4.2 Manipulation check: Scent induction

The ambient scents should be induced above odor detection threshold, but below odor identification. A question with open-response format indicated that in the control group (group without induced scents), no participant reported smelling a significant scent. One person in the control group (4.3%) perceived a general fresh fragrance, which signals that the odor neutralizer that was applied in the control group successfully removed any unpleasant scents. In the two scented conditions, 18 subjects (36.7%) mentioned that they could smell a scent (63.3% did not). In the scented nature condition, participants mentioned more general smell of 'freshness', 'sweet' and 'not known' as well as specific smell of 'flowery', 'lemon', and ‘lavender’ which fit to the visually presented park scenario. In the scented lounge condition, participants mentioned the more general smell of ‘sweet’ and ‘not known’ as well as the specific smell of ‘sandalwood’, and ‘peach’, which are seen as typical indoor odors. Overall, the mentioned scents differed between the two scented conditions and fit rather well to the presented visual stimuli. As expected, a precise odor identification was not possible.

4.3 Manipulation check: Resource depletion

To test whether the work during the depletion phase indeed depleted participants’ personal resources, a 2(time: t1 vs. t2) x 5(condition) ANOVA on the subjective measures of the resources was conducted. As expected, participants’ fatigue increased ($F = 45.24$, $p < .01$, $\eta^2 = .28$) and mood decreased ($F = 12.07$, $p < .05$, $\eta^2 = .09$) from t1 to t2, indicating depletion. Arousal also decreased from t1 to t2 ($F = 4.28$, $p < .05$, $\eta^2 = .04$). Together with the decrease in mood, this drop in arousal is interpreted as an exhaustion response. Moreover, unexpectedly, the interaction between time and condition yielded a significant effect on mood ($F = 2.77$, $p < .05$, $\eta^2 = .09$; there were no other significant interaction effects or main effects of condition). Apparently, the depletion effect was stronger in some conditions than in other. Since preceding depletion can influence the need for recovery and, hence, the intensity of the recovery effect, we included the depletion effect (t2: after demanding tasks minus t1: before demanding tasks) as control variable in the analyses of recovery effects. This procedure is consistent with previous studies (e.g., Smolders and de Kort 2014).

4.4 Hypotheses testing: Resource restoration

4.4.1 Effects on comfort of the break room and restorative experience

Table 2 provides an overview of correlations between environment, perception of the break room conditions, and recovery of personal resources using indicator coding for conditions. SEBEs simulating nature were perceived as more pleasant in view (r = .74, p < .01) and more restorative (r = 39, p < .01) than the standard break room. This supports H1a. Moreover, SEBEs simulating a lounge were perceived as more pleasant in view (r = .38, p < .01) than the standard break room. This supports H2a. In addition, correlation analyses showed that the view was perceived as more pleasant (r = .53, p < .01) and the environment as more restorative (r = .22, p < .05) in the nature simulations than in the lounge simulations. These results support H3a. In addition, environments with congruent ambient scents were perceived as marginally more pleasant (r = .18, p < .10) than the neutralizing scents. This result suggests support of H4a.

4.4.2 Indirect effects on recovery

Table 3 depicts the results of mediation analyses. The first mediation model (Model 1) tested whether SEBEs promoted personal resources through restorative experience (H1b and H2b). Results of Model 1 yielded a significant indirect effect on all three personal resources. This indicates that SEBEs improve perceived fascination and being away, which in turn decreases arousal and fatigue, and increases mood (see Table 3, Model 1). Overall, this supports H1b and H2b.

The second mediation model (Model 2) tested whether the simulated nature environment promoted personal resources through perceived fascination and being away (H3b) compared to an indoor break environment. Results of Model 2 yielded significant effects of the simulated environment on restorative experience, and significant indirect effects on all three personal resources. This indicates that the natural environment was perceived as more restorative than the indoor environment, which in turn facilitates the recovery of personal resources by decreasing fatigue as well as arousal and increasing mood (see Table 3, Model 2). Overall, this supports H3b.

The third mediation model (Model 3) tested whether SEBEs with congruent scents were linked to personal resources through the sequential mediation of perceived scent pleasantness and restorative experience (H4b). Results of Model 3 yielded significant indirect effects through pleasantness of scent on restorative experience and, in turn, on all three personal resources. This indicates that the greater pleasantness of scented environments fosters perceived fascination and being away, which in turn increases mood, and decreases arousal and fatigue (see Table 3, Model 3 and Fig. 3 for a graphical depiction). Overall, the results support H4b.

5. Discussion

The aim of the current study was to explore the restorative potential of SEBEs, particularly focusing on the simulated environment and sensory input. Results support our idea that sensory-enriched environments can facilitate the recovery of personal resources through individual’s perception of a room. In particular, the simulated nature and the simulated indoor break room were perceived as more restorative than the standard break room, which in turn enhanced the recovery of personal resources. However, the benefits for the simulated indoor break room compared to the control group was only significant for pleasantness of window view. All other variables (e.g. pleasantness of sound) were not significant. Viewing a natural environment was perceived as more pleasant for sensory input and more restorative than viewing a lounge environment, which in turn increased recovery effects. Finally, adding a congruent ambient scent resulted in increased recovery of personal resources through the sequential mediation of perceived scent pleasantness and perceived fascination/being away. Overall, our proposed conceptual model (see Fig. 2) was confirmed using various dependent variables. The results indicate that simulating restorative environments in a break room may promote recovery best by creating sensory-rich impressions of natural environments.

5.1 Implications and strengths of the current research

The present study offers two central implications. First, in past research on SEBEs, studies have often focused on restorative experience or on resource recovery as dependent variables. In contrast, we outlined the psychological pathway from specific environmental stimuli through perceived fascination and being away to recovery. In line with past research (Dahlkvist et al., 2016; Lindal & Hartig, 2013), we found that perceived fascination and being away represent important mediators in the relationship between the environment and the recovery of personal resources.

Second, the current study is one of the first to reveal the recovery process of an outdoor or indoor simulated environment for personal resources through various sensory impressions (vision, audition, and olfaction). Adding a congruent ambient scent increases the restorative potential of the simulated environment, which goes beyond simple visual or audiovisual stimuli (see also de Kort and IJsselsteijn 2006). Our study was able to show that using an additional congruent scent enhanced the room pleasantness of the simulated audiovisual environment and indirectly intensified the recovery effects on mood, arousal, and reduced fatigue. The influence of scent on mood might be due to the direct connection between the olfactory bulb and the limbic system (Bosmans 2006; Krishna 2012), and is in line with previous research showing that ambient scents foster positive mood (Baron 1983, 1986, 1990; Herz 2004; Michon, Chebat, and Turley 2005; Spangenberg et. al, 1996). Moreover, in line with Bensafi et al. (2002), participants' arousal decreased for participants who liked the ambient scent. The current data also strengthens Herz's (2009) conclusion that the pleasantness of an ambient scent determines its relaxing potential.

One strength of the current ambient scent simulation is the fact that many previous studies only investigated ambient scents compared to conditions with 'normal air.' In contrast, we investigated a subtler manipulation by using a neutralizing scent in the unscented conditions and a congruent ambient scent in two different scented conditions. We used this conservative design due to the fact that laboratories typically lack windows and tend to have stuffy air. Moreover, in field studies it is almost impossible to provide an environment without any ambient scents, hence including an uncontrolled variety of smells produced by subjects or objects. Thus, previous studies presumably compared any ambient scents (or even unpleasant air) to pleasant, congruent ambient scents, which may result in stronger effects than comparison of neutral air (control condition and conditions without olfactory input) with pleasant, congruent scents as done in this study. Therefore, our effects of scent may be interpreted as being strong, as they are discernible despite the current conservative design.

5.2 Limitations and future research questions

First, the value of indoor environments for recovery could not finally be answered with the current study. Although the lounge condition outperformed the control group with respect to pleasantness of view, there were no differences in other correlation measurements. Thus, further studies are needed to replicate our results.

Second, the generalizability of the present research may be limited due to the laboratory setting and the student sample. However, previous research has shown comparable restorative effects of nature in laboratory and field studies with diverse samples (e.g., Felsten 2009; Friedman et al. 2008). Third, during the depletion phase all participants worked on cognitive tasks that resemble vocational-like stress (but not interpersonal stress). The study from Gulwadi (2006) gives some first hints that natural environments might be more suitable for coping with vocational stress compared to home environments. Thus, the induction of vocational stress could be one reason why the lounge condition was evaluated less positively than the nature condition. Therefore, future studies might investigate different types of stress (e.g., vocational and interpersonal stress) separately. In addition, the restorative aspects of a lounge depend on the personalization of the environment (Richter 2008). Thus, further studies should investigate a personalized lounge, which could be used for several weeks before the study at the workplace.

Fourth, the study comprises a view of an indoor environment (lounge) through an artificial interior window vs. a view of an outdoor environment (nature) through an artificial window. At first glance it may seem unusual to use an interior window with a view of a lounge. However, in both sceneries, the aim of the artificial window was to facilitate detachment from work by offering a sensory input which offered distraction from the former work setting. In both sceneries, it was obvious that we used an *artificial* window which could show any environment, including a lounge. Our intention was to demonstrate that people prefer the view offered by an artificial window compared to no window view.

In this, the current study does not recommend replacing real windows with artificial windows. Instead, we seek to point out the possibilities of equipping windowless rooms with artificial windows to enhance the room's restorative potential. Nowadays people use many artificial devices to simplify and improve their lives (e.g., navigation devices to orient themselves in an unfamiliar environment, or a TV to relax). In this context, artificiality is not perceived in a negative way. Thus, we assume that in the future, when artificial windows become even more realistic, they will stand for a positive experience which fosters life quality (such as higher degree of privacy, no one can see inside the room) and higher scope for decision making since every kind of environment can be simulated.

Fifth, it remains unclear whether some natural environments are more suitable than others for use as simulations in break rooms. In the current study, individuals were confronted with mundane nature (instead of spectacular nature, like impressive waterfalls or spectacular mountains). This practice evolved based on the assumption that only soft fascination (a low to moderate level of arousal) could foster restorative processes, whereas hard fascination would lead to high levels of arousal, which could be a barrier to restoration (Kaplan 1995; Kaplan and Berman 2010). Contrary to this expectation, a recent study (Joye & Bolderdijk 2015) investigated extraordinary nature (with a higher degree of fascination or even hard fascination) compared to mundane nature (soft fascination), and found beneficial effects from extraordinary nature regarding the degree of beauty, awe, and positive mood change.

However, they also found negative effects concerning levels of fear. Therefore, further studies are needed to answer the question of whether extraordinary or mundane nature has the greater restorative potential. In addition, the degree of vocational exhaustion should be taken into account: humans who are completely exhausted may prefer relaxing, calming environments such as mundane natural environments, whereas individuals who are only slightly exhausted might prefer a higher degree of stimulation provided by extraordinary nature.

5.3 Practical implications of the current research

The present research provides practical implications for the design of numerous interior spaces, such as break rooms, waiting areas, or workplaces without windows (or without an attractive view) and without scents (or with unpleasant scents). This involves underground and shift workplaces which have no daylight or fresh air, but it also contains break rooms located inside hospitals, where nurses and physicians work at night and without window views. Retirement homes, too, could profit from artificial windows and pleasant congruent scents. Older individuals are often no longer mobile enough to regularly access real environments. Thus, the opportunity to use artificial environments inside retirement homes could strengthen their quality of life. Further, in hospitals or retirement homes, unpleasant smells are often present due to medicines, open wounds, or poor hygiene. As a result, physicians and nurses have to cope with these unpleasant smells, potentially resulting in decreased personal resources. Additionally, patients' relatives do not enjoy visiting hospitals with unpleasant odors, and sick persons may not be able to focus on recovery while coping with unpleasant stimuli. Thus, the use of pleasant ambient scents to mask smells or to generate restorative environments could be beneficial to enhance patients', physicians', nurses', and visitors' well-being.

It has to be noted that some humans have chemical sensitivities that might disallow use of scents in enclosed work spaces or break rooms. However, the levels of ambient scents used in the current study are relatively low, just above perceptual threshold. Hence, as long as individuals do not get allergic reactions in real natural or lounge environments, they should not suffer from allergic reactions in the current simulated environments with ambient scents.

Moreover, with respect to movement in closed spaces such as airplanes, trains, or subways, artificial windows and pleasant congruent scents could enhance the restoration experience and subsequently improve mood, cognitive performance, and physiological functioning (Friedman et al. 2008). In particular, traveling by plane or train causes some people to feel uncomfortable or experience fear (e.g., Kahan et al. 2000). The use of artificial windows and pleasant congruent scents could distract and relax, therefore helping to withstand stressful events (Kline 2009).

Finally, simulations of restorative environments may also be useful to improve recovery during work breaks. Employees could bring along their own favored pictures, e.g., from a vacation. These pictures could be presented in an artificial window, accompanied by a pleasant congruent scent to foster the replenishment of depleted resources. Moreover, it may not even be necessary to build an artificial window. Instead, more convenient means of presenting audiovisual simulations such as virtual reality headsets may also be able to support recovery and may even provide a deeper immersion in the scene (de Kort, 2006).

In summary, it can be concluded that recovery may begin with the vision of an environment, but flourishes from sensory-enriched, pleasant impressions.

Footnotes

[1] This paper is based on the third chapter of the doctoral thesis (Sona, 2017). It represents an enhanced version regarding theory, previous research, analyses and discussion.

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Figure 1. Restoration room environments. Left: Lounge scenario. Right: Nature scenario.

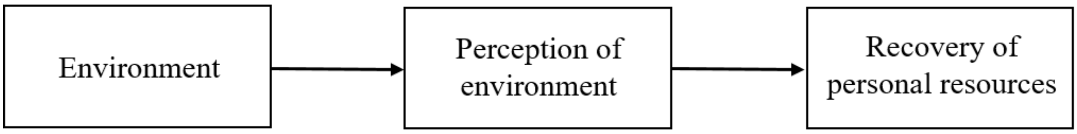

Figure 2. Conceptual Model. Hypothesized causal chain of physical environment on recovery of personal resources through perception of environment.

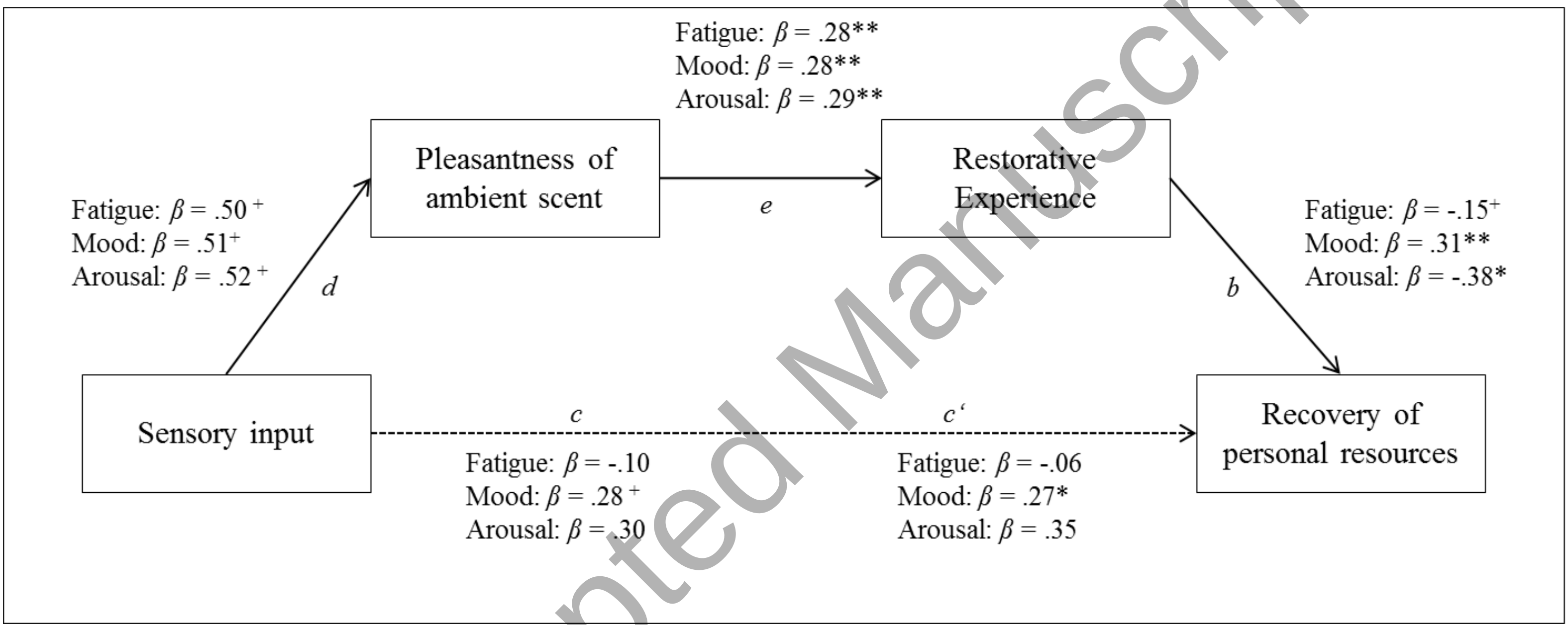

Figure 3. Model 3. Scented conditions (= 1) vs. unscented conditions excluding control group (= 0) on personal resources (mood, arousal, and fatigue) are mediated by pleasantness of ambient scent (path d), followed by restorative experience (fascination/being away (path e). *c* = direct effect from sensory input on personal resources without mediators. *c'* = direct effect from sensory input on personal resources including mediators. N = 89. $^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$. For comparisons with Table 3, the paths are labelled in the same denomination.

Table 1. Perception of the break room and personal resources: Means and standard deviations.

	Control group	Unscented Nature	Unscented Lounge	Scented Nature	Scented Lounge
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Fatigue					
t1	2.10 (0.86)	2.12 (0.92)	2.04 (0.89)	2.33 (1.14)	2.08 (0.94)
t2	2.97 (1.59)	2.69 (1.02)	2.20 (1.05)	2.94 (1.26)	2.94 (1.13)
t3	2.32 (1.20)	2.08 (0.80)	1.77 (0.84)	2.21 (0.86)	2.94 (1.13)
Mood					
t1	3.59 (1.17)	3.71 (1.03)	3.69 (1.02)	3.57 (0.98)	3.73 (0.95)
t2	3.42 (1.32)	3.37 (1.04)	3.69 (1.07)	3.52 (1.08)	3.07 (1.18)
t3	3.73 (1.31)	3.85 (0.91)	3.83 (1.05)	3.95 (0.90)	3.76 (1.22)
Arousal					
t1	2.72 (0.87)	2.95 (0.76)	2.60 (0.73)	2.68 (0.88)	2.40 (0.80)
t2	2.42 (0.70)	2.74 (0.80)	2.45 (0.71)	2.61 (0.96)	2.42 (1.00)
t3	2.10 (0.68)	2.29 (0.68)	2.22 (0.69)	2.22 (0.70)	2.03 (0.77)
Perception of the break room					
Odour Pleasantness	5.00 (1.52)	4.73 (1.20)	4.71 (1.45)	5.36 (1.22)	5.00 (1.48)
Restorative experience (fascination/ being away)	2.81 (1.11)	3.68 (.94)	3.12 (1.28)	3.74 (.94)	3.42 (.96)

Note. t1: before demanding tasks; t2: after demanding tasks; t3: after break room.

Table 2. Correlations between environment, room perception, and recovery of personal resources.

		Nature	Lounge	Simulated environment	Sensory input				
		nature = 1; control group = 0	lounge = 1; control group = 0	nature = 1; lounge = 0	scent = 1; no scent= 0				
		n = 62	*n* = 58	*n* = 99	*n* = 99	1	2	3	4
	Pleasantness								
1	…View	.74**	.38**	.53**	-.03				
2	…Sound	.19	.23	.01	.14	.29**			
3	…Odor	.02	-.05	.08	.18+	.16	.21*		
4	Restorative experience	.39**	.18	.22*	.10	.57**	.38**	.35**	
	Personal resources								
	… Fatigue	-.09	-.11	-.03	-.02	-.09	-.11	-.22*	-.23*
	… Mood	.09	-.06	.08	.13	.09	.24*	.13	.45**
	… Arousal	-.07	.10	-.17	.09	.49**	.16	.01	.24*

Note. $^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$. The values of personal resources are difference scores between t2 to t3 indicating restoration; controlling for the amount of depletion (t1 to t2). t1: before demanding tasks; t2: after demanding tasks; t3: after break room. Correlations between room pleasantness/restorative experience (fascination/being away) and personal resources are calculated with sensory enrichment, including both nature and lounge environments. Indicator coding for nature (nature conditions = 1, control group = 0), lounge (lounge conditions = 1, control group = 0), simulated environment (nature conditions = 1, lounge = 0) and sensory input (scented conditions = 1, unscented conditions = 0; Hayes & Preacher, 2014).

Table 3. Unstandardized coefficients for the results of the ordinary least squares regression analyses.

									Indirect effect		
										Bias-corrected bootstrapped 90% *CI*	
Model	Criterion	*N*	Total effect (c)	Direct effect (*c′*)	Path *a*	Path *b*	Path *d*	Path *e*	PE	*SE*	LL	UL
Model 1: Sensory enriched conditions vs. control group	Fatigue	120	-.16	-.06	.63*	-.15*			-.09	.05	-.25	-.02
	Mood	120	.09	-.10	.67**	.28**			.19	.08	.04	.36
	Arousal	120	.02	.21	.65**	-.30**			-.19	.11	-.49	-.04
Model 2: Nature vs. lounge conditions	Fatigue	97	-.03	.03	.47*	-.17*			-.08	.05	-.21	-.01
	Mood	97	.05	-.02	.47*	.28**			.13	.06	.02	.28
	Arousal	97	-.40	-.25	.46*	-.32**			-.15	.09	-.41	-.02
Model 3: Scented vs. unscented conditions	Fatigue	89	-.10	-.06		$-.15^{+}$	$.50^{+}$	.28**	-.02	.02	-.07	-.001
	Mood	89	$.28^{+}$	.27*		.31**	$.51^{+}$	.28**	.04	.03	.0004	.12
	Arousal	89	.30	.35		-.38*	$.52^{+}$	.29**	-.05	.04	-.16	-.001

Note. Confidence intervals are bias-corrected and based on 10,000 bootstrapped resamples. All analyses controlled for the amount of depletion (t2 – t1). PE = point estimate of indirect effect, *SE* = standard error of indirect effect, *CI* = confidence interval. LL = lower limit, UL = upper limit. All path coefficients (*a*, *b*, *c′*, *c*, *d*, *e*) are unstandardized. All models are free from multicollinearity (all VIF ≤ 4.0). $^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$.

Path *a*: independent variable on restorative experience (fascination/being away); path *b*: Restorative experience on criterion; path *c*: independent variable on criterion calculated without mediators; path *c'*: independent variable on criterion calculated with mediators in the model; path *d:* independent variable on scent pleasantness; path *e*: scent pleasantness on restorative experience. Model 1: First mediation model, tested whether SEBEs promoted personal resources through restorative experience (H1b and H2b). Model 2: Second serial mediation model, tested whether the simulated environment promoted restorative experience (H3b). Model 3: Third sequential mediation model, tested whether SEBEs with congruent scents were linked to personal resources through the sequential mediation of perceived scent pleasantness and restorative experience (H4b).