With all my senses:
Restorative environments through holistic sensory impressions

by

Brid Sona

A thesis presented to the University of Hohenheim in partial fulfillment of the thesis requirement for the degree of Doctor rerum socialium (Dr. rer. soc.) in Psychology

Supervisor and primary reviewer of the doctoral thesis: Prof. Dr. Anna Steidle
Secondary reviewer of the doctoral thesis: Prof. Dr. Sabine Trepte
Chair of the defense: Prof. Dr. Marion Büttgen
Dean of the Faculty of Business, Economics and Social Sciences: Prof. Dr. Karsten Hadwich

Submitted on 14.07.2017 Thesis defense on 07.11.2017

Acknowledgments

I would like to acknowledge the contribution of my supervisor, Prof. Dr. Anna Steidle, for her support and commitment throughout all stages of my thesis. We learned together to manage stressful days with a lot of humor and serenity, without losing sight of the essentials. Thank you so much for this experience! In addition, sincere thanks go to Prof. Dr. Sabine Trepte, the secondary reviewer of my doctoral thesis. Thank you for your interest in my work!

I would also like to express my appreciation to Prof. Dr. Lioba Werth, who gave me the opportunity to be part of the interdisciplinary research team 'People Inside' and the chair of Industrial and Organizational Psychology at the University of Hohenheim. Without her support, this doctoral thesis could not have been achieved. Thank you very much indeed!

Special thanks go to my awesome colleagues at the University of Hohenheim and the Graduate Program 'People Inside' for the scientific exchanges and countless hilarious lunches. I definitely learned what it means to share responsibility and that I can always rely on your encouragement. Thank you so much! Special gratitude goes to Konrad Senf, Olga Kombeiz, Hannah Helfrich, Cathrin Dieckhoff, and Sertac Karacan for reading parts of the thesis. Finally, my greatest thanks must go to my family, my sources of love and energy. Thank you for always being there for me.

Abstract

Growing awareness of psychological health problems is resulting in various research areas exploring new approaches to fostering personal resources. Restorative Environments Theory (RET) has shown that mundane natural environments support personal resources. Although other restorative environments may exist besides mundane natural environments, their systematic examination is still lacking.

In the real world, users experience environments through all their senses. However, most of the recovery research focuses on investigation of single sensory impressions. Thus, concrete insights into how various ambient qualities of an environment may affect users' perception are still needed.

The main aim of this doctoral thesis is to enhance the existing theoretical framework of restorative environments and to give an overview of research while pointing out where more research is needed. Further, the thesis includes identification of restorative environments and their specific ambient qualities. Based on the explored environments, the present research will point out psychological pathways to obtain recommendations for the design of restorative environments.

The first research project was an explorative study to identify restorative places and their ambient qualities. In accordance with restoration research, participants described natural outdoor environments which they sought for recovery. In addition, they described indoor environments. Depending on the type of depletion and the environmental setting, specific environments and ambient qualities were evaluated as more important for the restorative potential of the place than others. This explorative research supports theory building and enables creation of restorative environments through holistic sensory impressions. Finally, strengths, limitations and practical implications for designing and improving restorative environments are discussed.

The second research project takes up the findings of the first project by simulating sensory-enriched break environments. Based on the impact of holistic sensory impressions, this project is one of the first to reveal the impact of the recovery process of simulated environments on personal resources through congruent sensory impressions. Analyses confirmed that sensory-enriched environments were perceived as more pleasant and more restorative than less enriched environments, which in turn facilitated the recovery of personal resources. The results point out the relevance of holistic sensory impressions to fostering recovery. Implications and limitations of sensory enrichment in break environments are discussed.

To broaden generalizability, the third research project comprises three field experiments investigating recovery during break interventions which offered virtual restorative environments with differing degrees of immersion and different types of environments. Building on previous research (Grimshaw, 2014), the third project posited that a higher degree of immersion in the simulated environment increases perceived realism, which becomes apparent in higher positive perceptions and recovery outcomes. Moreover, environments with different degrees of stimulation were anticipated to evoke distinct successful recovery. Previous research had mainly focused on calming environments for recovery. Additionally, this project also tested whether stimulating environments promote recovery outcomes. Results mainly confirmed the proposed hypotheses. The relevance of immersion and the impact of different types of natural environments on recovery are discussed.

Overall, the current research emphasizes the impact of holistic sensory impressions in enhancing positive perceptions of the environment and, consequently, various recovery outcomes. The conducted studies uncover the psychological pathway from the processes of sensory perception to environmental recovery perception, followed by recovery outcomes. Beside these theoretical insights, the current research delivers concrete recommendations for designing restorative (virtual) environments in the workplace.

Contents

List of abbreviations

ART: Attention Restoration Theory

HMD: Head mounted display

JD-R: Job Demands-Resources

PET: Psycho-Evolutionary Theory

PRP: Perceived restorative potential

RET: Restorative Environments Theory

SEBE: Sensory-enriched break environment

SRT: Stress Recovery Theory

VR: Virtual Reality

Preface

Imagine a world with the most beautiful views. Imagine you are walking through a park, seeing all the splendors of nature. You gaze at colorful flowers and lush green grass. You can see birds flying in the blue sky, and are dazzled by the glory of the sun. You feel completely overwhelmed by the beauty of this place. But all of a sudden, you realize that something crucial is missing. From this moment on, your thinking is determined by an inner restlessness and anxiety. Now you realize that you cannot hear the birds singing. You cannot smell the scent of the flowers. And you cannot feel the warm breeze on your skin. Your thoughts circle around these mysterious impressions, reflecting and speculating. Finally, you come to the conclusion that there can be only one explanation for this strangeness: this world cannot be real.

This preface describes why we should think in holistic terms, instead of considering individual sensory impressions while neglecting others. The current doctoral thesis builds on a holistic approach and aims to explain the impact and interaction of specific sensory impressions on restoration.

Chapter 1: General Introduction

The world of work has already recognized the enormous impact of human health and well-being on ensuring long term success. There is great interest in finding new ways to prevent health problems and to promote individuals' resources (e.g., corporate wellness programs; Mujtaba & Cavico, 2013). During recovery, people replenish their depleted resources (Sonnentag, & Zijlstra, 2006). Without periods of recovery, mental fatigue, exhaustion, and consequently, reduced performance at work occur (Trougakos & Hideg, 2009). One way to strengthen personal resources is to provide restorative environments fostering recovery processes.

Among social, psychological, or organizational factors which are mentioned as potential resources in the *Job Demands-Resources (JD-R)* model (Bakker & Demerouti, 2007; Demerouti et al., 2001), the physical environment represents a crucial factor in recovery (e.g., Ulrich, 1991; Huisman, Morales, van Hoof & Kort, 2012). Previous research has been able to show that natural environments facilitate recovery. Since many employees have no access to natural environments during work breaks, researchers and practitioners are increasingly interested in creating restorative environments directly at the workplace. However, so far, there is no systematic evaluation of what kind of environment is appropriate for recovery at the workplace. Past studies have predominantly focused on visual and acoustic simulations, preferably of nature, and have found positive recovery effects. However, the question remains open as to whether these recovery effects can be increased with the help of more congruent ambient impressions - thus, with a more realistic atmosphere. Hence, the current thesis attempts to present a contribution toward elucidating the following facets of restorative environments at the workplace.

First, the current thesis will identify various restorative environments by applying an explorative approach. Second, building on these findings, the impact of congruent ambient impressions on recovery will be tested, exploring the underlying psychological processes. Third, in order to achieve different degrees of perceived reality, the conducted studies vary in terms of the technical devices used as well as the conditions of the settings, from highly standardized laboratory simulations to systematic research under natural conditions at real workplaces.

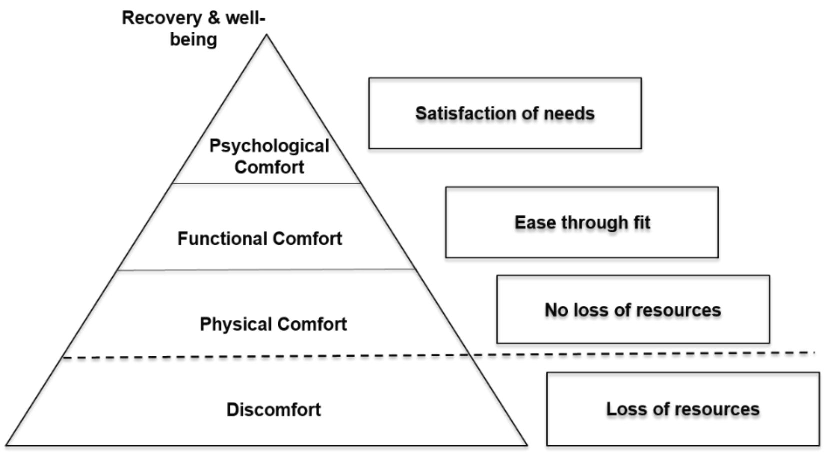
Chapter 1 of the current thesis will present a theoretical framework of restorative environments and an overview of previous research. Subsequently, the proposed underlying psychological pathway to illuminate environmentally induced recovery effects will be illustrated. The incremental value and the aim of the thesis will then be presented, followed by an outline of the three research projects conducted. Chapters 2, 3, and 4 describe the three research projects in detail. Finally, Chapter 5 will conclude the thesis with a general discussion.

1.1 Person-environment-fit

Environments can support individuals' wellbeing and satisfaction when they match the individuals' intended activities and needs. In organizational psychology research, this match is also called 'person-environment fit' (e.g., Edwards, Cable, Williamson, Schurer Lambert, & Shipp, 2006). Environments are perceived as restorative if they enable restorative perceptions or recovery activities: for instance, going for a walk in a natural environment, meeting friends in a coffee room, or napping on a couch recliner (Sona & Steidle, 2016). In the present thesis, the term *perceived restorative potential (PRP)* will be used for restorative perceptions.

Vischer's habitability pyramid (2007) describes essential parameters for strengthening the perceived match between the environment and individual needs (see Fig. 1, adapted from Vischer, 2007; Steidle, de Boer, Werth, & Sedlbauer, 2014; Sona & Steidle, 2016). The pyramid indicates three levels of comfort. (1) *Physical comfort* entails basic human needs, such as health or safety. A loss of basic needs can result in *discomfort*. For instance, an unpleasant noise might lead to cognitive depletion and thereby elicit discomfort. This perceived discomfort causes compensation strategies which consume additional resources, such as time or self-control, and lower the PRP of an environment as a result. (2) If environments support individuals in performing intended actions (such as recovery), they provide *functional comfort*. For instance, an environment's 'park' or 'garden' encourages going for a walk, and a 'lounge,' offering a cozy couch, supports relaxation (Sona & Steidle, 2016). (3) Further, environments offering privacy or the ability to control ambient qualities/features can enhance *psychological comfort.* For instance, a break room in which people feel observed is generally perceived as less restorative than a room with some privacy (Vischer, 2007; Sona & Steidle, 2016).

Fig.1. Habitability pyramid (adapted from Steidle et al., 2014).



An environment that fulfills all three levels of comfort is perceived as highly restorative. Unpleasant stimuli, such as an unpleasant ambient odor, could hamper recovery on all levels of comfort. For instance, a person exposed to an unpleasant odor has to consume resources to block out the odor (physical level). Moreover, the odor interferes with recovery activities like relaxation (functional level), and is perceived as beyond control (psychological level). Thus, adequate places for recovery should take into account a good match between personal needs and the presented ambient qualities (Sona & Steidle, 2016).

1.2 Restorative Environments Theory

Restorative Environments Theory (*RET*, White, 2013) received attention from various disciplines. It assumes that visually pleasant environments encourage positive impacts on recovery. RET can be divided into two prominent approaches: *Attention Restoration Theory* (*ART*; Kaplan & Kaplan, 1982) and *Stress Recovery Theory* (*SRT*, also known as *Psycho-Evolutionary Theory*, *PET*, Ulrich, 1983). Both theories propose that exposure to natural environments can promote recovery of depleted resources. However, the focus lies on different types of resources: ART concentrates on *cognitive resources* in the form of directed attention, whereas SRT emphasizes *emotional resources* differing in arousal and valence.

With respect to ART, two types of attention are distinguished, *direct* (or *voluntary*) vs. *indirect* (or *involuntary*) attention. During work, 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). ART postulates that indirect attention replenishes depleted resources of directed attention (Berman, Jonides, & Kaplan, 2008). During indirect attention, no conscious control is consumed, and therefore cognitive resources regain pre-fatigue levels (Berman, Jonides, & Kaplan, 2008; Kaplan & Kaplan, 1982; Kaplan & Berman, 2010). For instance, people viewing beautiful natural scenes will immediately be attracted by the fascinating stimuli. Thus, no direct attention is needed.

In contrast to ART, SRT (Ulrich et al., 1991; Ulrich, 1983) proposes that natural environments foster positive affect and lower negative affect (Berman et al., 2008; Hartig et al., 2003; Ulrich et al., 1991). These mechanisms facilitate stress recovery (physiological arousal) to pre-stress levels. SRT assumes that humans evolutionary prefer places which ensure survival (e.g., the availability of food and water) and well-being (e.g., stress-free places, providing resources). In other words, for recovery, humans prefer places that are non-threatening. These conditions are generally more likely to be found in natural environments (Ulrich et al., 1991).

A significant body of research tested both theories and confirmed that certain natural environments are indeed perceived as more restorative than urban environments. Studies showed that natural environments increase positive moods (Beute, & de Kort, 2014; Berman et. al, 2008; Hartig et al., 2003; Ulrich et al., 1991). For instance, Beute and de Kort (2014) found that after performing a depleting task, viewing natural scenes improved the participant's mood. Moreover, studies found beneficial effects on physiological arousal (Beute, & de Kort, 2014; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Ulrich et al., 1991). For instance, in the study by Beute and de Kort (2014), exposure to natural scenes lead to a larger decrease in heart rate variability (LF/HF ratio) than exposure to urban scenes. Further, research was able to show better cognitive functioning in natural than in urban environments (Beute, & de Kort, 2014; Berman et al., 2003; Hartig et al., 2003; Ulrich, 1979; Hartig, Mang, & Evans, 1991). For instance, Beute and de Kort (2014) found positive effects on impulse control after subjects viewed pictures of nature compared to urban scenes. 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 for personal resources. However, Kaplan (1992) did not define which specific elements of nature, e.g., colors or scents, are crucial for recovery.

Taking a first step in this direction, subsequent studies explored the role of colors and highlighted the impact of 'green spaces' on recovery. For instance, Maas et al. (2006) showed that there is a positive association between green space and the perception of health. However, a recently conducted study pointed out that children in a schoolyard evaluated the color of orange foliage as equally restorative as the color of green foliage (Paddle & Gilliland, 2016). Thus, further research is needed to clarify the specific ambient qualities of environments (e.g., colors, lightings, or scents) which are actually perceived as restorative.

1.2.1 Simulated environments, congruent impressions, and immersion

Previous research has outlined that natural environments are particularly highly restorative. Thus, the best place to spend a work break should be an actual natural setting. However, during work breaks people do not always have the option or time to go to real natural environments. Inside buildings, people could benefit from simulations of restorative ambient surroundings, which can be achieved through new technological devices like screens, artificial windows, or virtual realities.

Several studies investigated possibilities of enhancing connectedness with nature inside the building, for example through window views or pictures of nature, and found positive effects on attention (Berman et al., 2008), executive performance (Tennessen & Cimprich, 1995), and mood (Berman et al., 2008; Berto, 2005; Hartig et al., 2003; Ulrich et al., 1991). For instance, Kjellgren and Buhrkall (2010) compared the restorative effects of a slideshow of nature vs. real nature and indeed found more positive effects for real environments, but also significant stress reduction through the slideshow. In another study, 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 contrast, Kahn, Severson and Ruckert (2009) demonstrated that only a real window onto nature was beneficial for recovery: Participants were either seated in an office room, seeing either a real window looking onto a natural setting or a plasma monitor showing the same natural view in real time, or seated in a windowless room. Only participants with the real window view indicated heart rate recovery.

The differing results from the studies mentioned could be due to a lack of perceived realism of the simulated window views. Only visual impressions were used, neglecting further sensory impressions which could have enhanced perceived realism and provided a restorative atmosphere. As mentioned earlier, an authentic experience of a simulated environment may well require further sensory impressions beside a pure vision, such as acoustics, smells, or temperature (Depledge, Stone, & Bird, 2011). The absence of some impressions when they are normally expected, e.g., the sound of birdsong while seeing birds, reduces the perception of reality and could thereby result in a negative impact, like a reduced PRP of the environment (de Kort & IJsselsteijn 2006; Depledge et al., 2011; Kjellgren & Buhrkall, 2010). Hence, restorative places such as break rooms at work should strive to offer realistic atmospheres. In line with that reasoning, some studies used combinations of congruent visual and acoustic stimuli (e.g., views of nature and birdsong) to strengthen perceived reality, and found positive recovery effects (Annerstedt et al., 2013; Alvarsson, Wiens, & Nilsson, 2010).

Similarly, freedom of movement (e.g., the possibility of turning the head in every direction) in a simulated environment can promote immersion in the simulation presented and the experienced realism or presence (Grimshaw, 2014). Thus, higher immersion may trigger positive perceptions, which in turn may foster recovery of depleted resources. An evaluation of environmental qualities can be used to determine positive perceptions. The current thesis will further show that the same amount of sensory impressions (e.g., auditory and visual) has different recovery effects depending on the degree of immersion induced through the technical device used. To date, only a few studies have investigated an increase in immersion and the consequences for recovery (de Kort & IJsselsteijn, 2006). Hence, there is a need for further research.

Building on these promising findings, the present thesis investigates systematic manipulation of sensory impressions, particularly those from vision, audition, olfaction, and freedom of movement, and illuminate how these impressions contribute to recovery effects.

1.2.2 Type of environment

According to RET, natural environments are evaluated as more restorative than urban environments (Hartig et al., 1996), and outdoor environments are evaluated as more restorative than indoor environments (Weng & Chiang, 2014; Hug, Hartig, Hansmann, Seeland, and

Hornung, 2009). However, some indoor environments (e.g., home environments) may offer similar or even greater PRPs than natural outdoor environments. For instance, teenagers like to listen to music, sleep, or chat with friends on the internet, and thereby reduce stress or negative mood (Weng & Chiang, 2014). Moreover, the concepts of territoriality, privacy, and autonomy which entail psychological comfort are well fulfilled in home environments (Richter, 2008; Vischer, 2007). Thus, further research is needed to discover the beneficial effects of indoor vs. outdoor environments on recovery.

So far, the focus of interest has been on the restorative effect of mundane nature (e.g., parks). However, it might be that spectacular natural scenery (e.g., impressive mountains) is perceived as equally restorative (Joye & Bolderdijk's, 2014). Up to now, there has been little research into spectacular natural settings because it was assumed that higher levels of arousal are rather obstructive for recovery (Kaplan, 1995; Kaplan and Berman, 2010). This conclusion is in contrast to human interest in spectacular nature, for instance, on vacation or weekends. Thus, there must be some qualities of spectacular nature which humans perceive as pleasant or even restorative. The current research will therefore also give novel insights into the restorative potential of spectacular natural environments.

1.3 Pathways to recovery: Underlying psychological mechanisms

As detailed above, restorative environments can increase personal resources. But what processes occur between the first perception of an environment and the final recovery outcomes? The current thesis will point out pathways with the objective of gaining a deeper understanding into how restorative environments improve personal resources.

Humans evaluate an environment as pleasant or unpleasant. The perceived pleasantness impacts on how restorative environments are perceived (Alvarsson, Wiens & Nilsson, 2010; Bensafi et al., 2002; Doucé et al., 2014; Herz, 2004). ART assumes that there is no need for directed attention in esthetically pleasing environments (Kaplan & Kaplan, 2011) and therefore that pleasant environments finally foster the replenishment of depleted resources.

Besides pleasantness, ART postulates four qualities of restorative environments which are also perceived before recovery outcomes occur: being away, fascination, extent, and compatibility (Kaplan, 1995, 2001). *Being away* describes a mental or spatial detachment from environments which consume energy or resources. *Fascination* indicates an inherent interest in an environment which does not require direct attention. *Sense of extent* posits a coherence between all stimuli which enables immersion in the environment. Finally, *compatibility* details the fit between personal requirements and the environment (see also Chapter 1.1, person-environment fit). These four described qualities of restorative environments (Kaplan, 1995, 2001) mediate the effects on affect and happiness (Marselle, Irvine, Lorenzo-Arribas, & Warber, 2016). Thus, in line with previous research (Marselle et al., 2016), the current thesis will investigate perceived pleasantness and the four qualities of restorative environments (Kaplan, 1995, 2001) as potential mediators of various recovery outcomes.

1.4 Need for Further Research on Restorative Environments

In this context, four areas of research require further attention. First, previous research concerning restorative environments has mainly compared pleasant mundane natural vs. urban environments. However, urban environments are not likely to be restorative and there is only little research into other restorative environments beside mundane nature. Moreover, most of the past studies have predominantly investigated the impact of visual stimuli (e.g., Ulrich, 1984; Laumann et al., 2003). However, humans perceive an environment through all senses. So far, it is not clear which specific sensory element (e.g., color, lighting, or scent) is crucial for PRP and, in turn, for increasing recovery. Thus, further explorative and, subsequently, confirming research is needed to determine restorative environments and their ambient qualities.

Second, there is a need for further research to elucidate how simulations of environments need to be designed to foster recovery. For instance, the question arises of whether the presence of a pleasant ambient scent might be beneficial for recovery perceptions. Consequently, the current thesis will contribute to refining RET, providing recommendations for the design and simulation of restorative environments.

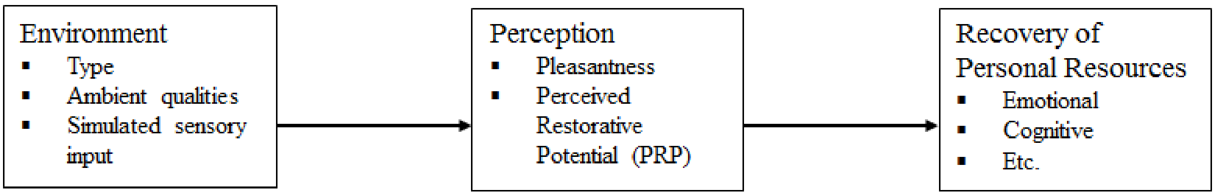
Third, only a few studies have manipulated the degree of immersion providing freedom of head movement in a simulated environment. Hence, to date it is not yet fully understood how different degrees of immersion foster recovery.

Fourth, the processes that are involved from the perception of an environment to the recovery reactions have not yet been finally clarified. Hence, the thesis will contribute to theory building indicating the underlying psychological mechanisms.

1.5 Aim of the Thesis

The aim of the present thesis was (1) to expand the theoretical framework of RET by identifying restorative environments and their ambient qualities, (2) to examine the benefits of sensory-enriched break environments for the recovery process, particularly focusing on the role of the sensory input and the simulated environment, and (3) to investigate the impact of different degrees of immersion on the recovery process. Overall, the present thesis assumes the research model depicted in Figure 2.

Fig. 2. Research Model.



This research will reveal theoretical insights by explaining the pathway from the simulated environment through perception processes to recovery of personal resources. Thereby, it is postulated that the environment will have positive effects on recovery of personal resources through pleasantness of sensory input and PRP.

With the aid of the qualitative research, the current thesis will allow further theory building. By means of the quantitative research, the thesis will result in theory testing and valid recommendations for designing restorative environments.

1.6 Overview of research

This doctoral thesis points out new theoretical ideas of RET (Chapter 2). The revised view of restorative environments as an interaction of pleasant, congruent impressions instead of pure nature (Chapter 3) and the consideration of different degrees of immersion for recovery (Chapter 4) represents a novel approach which will strengthen RET. Furthermore, the current thesis make a contribution to theory testing: Chapter 3 concentrates on a lab-based experiment, whereas Chapter 4 presents a transfer to the work context. Limitations of generalizability were tested including blue-collar and white-collar workers, testing people with a wide range of ages and different cultural backgrounds, and examining various times by testing night-shift and daytime workers.

To gain contributions to theory building, the first research project identified several restorative environments and their ambient qualities for replenishing emotional and cognitive resources. Based on previous research, it was expected that natural environments would be perceived as restorative. Besides, the explorative study identified several restorative indoor environments, and thereby provides a theoretical contribution to RET. Results are in accordance with previous research, but describe beyond the impact of indoor environments and distinct ambient qualities (e.g., specific colors) on PRP. Strengths, limitations, and practical implications of creating restorative environments are discussed.

The second research project applied the explorative research in a new setting of simulated environments. The project gives new insights into RET itself by simulating sensory-enriched break environments, focusing on the impact of simulated environment (natural outdoor vs. built indoor) and the degree of sensory input (no sensory input vs. audiovisual input vs. audiovisual and olfactory input). Results show that after cognitive depletion, participants recover more readily in a natural outdoor environment than a built indoor environment.

The research project verified the mediating effects of perceived pleasantness of the environment/the sensory input, which enhanced recovery perceptions, which in turn promoted recovery outcomes. In particular, adding a congruent scent to an audiovisual simulation indirectly supported the recovery of personal resources. This research project is one of the first explaining the recovery process of simulated environments for personal resources through congruent sensory impressions. Strengths and practical limitations of sensory enrichment in break environments are discussed.

The third research project transferred the findings of restorative natural outdoor environments to the work context. Generally, the weakness of field-based studies is the lack of control of all environmental factors that might affect the consequences of the independent variable. In the current research, this dilemma was resolved by using virtual realities (e.g., HMDs) in field-based experiments, banishing or at least reducing confounding variables by increasing the degree of immersion in the scene and allowing more valid measurements. Building on previous research, the current research expected that higher degrees of immersion would promote greater recovery effects. In addition, it was expected that both mundane and spectacular natural environments facilitate recovery.

Hence, a theoretical contribution was conducted by manipulating the degree of immersion (laptop screen vs. HMD) and the type of natural environment. Results mainly confirmed the proposed hypotheses. The impact of the degree of immersion and spectacular nature for recovery in the work context are discussed.

Chapter 2: A contribution to theory building: Exploring restorative environments

Guides to recovery:
Exploring ambient qualities' contribution to the perceived restorative potential of environments

Brid Sona

Abstract

Companies are showing an increasing interest in restorative environments to foster health and well-being. But which ambient qualities are important for restorative perceptions? In the current study, participants (*n* = 265) described places with *perceived restorative potential (PRP)* after emotional or cognitive depletion. Qualitative and quantitative methods were used to identify restorative places and their ambient qualities. As expected, participants reported that they imagined recovering more easily in natural environments (e.g., ‘park/ garden’), but also in indoor environments (e.g., ‘home’), depending on the type of depletion. Some ‘key elements’ contributed more to high PRP of a respective environment than others: for outdoor and indoor environments, participants emphasized ‘bright light’. Highlighting environments with high PRP and their distinct ambient qualities will help to identify and design places to support recovery.

Keywords: explorative study, restorative environments, sensory (key) elements, recovery

Introduction

Alongside its benefits, urban living has brought various health problems, including respiratory complaints (Eggleston, 2007), increased obesity (Flegal, Carroll, Ogden, & Curtin, 2010) and cardiovascular disease (Kruger, Venter & Vorster, 2003). Hence, there is a need for healthy environments in the urban world. In recent decades, environmental psychologists attempted to find environments that individuals prefer for recovery. They identified natural environments as highly restorative (e.g., Beute & de Kort, 2014a/b; Berman, Jonides, & Kaplan, 2008; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Ulrich, Simons, Losito, Fiorito, Miles, & Zelson, 1991). However, the distinctive features of these 'restorative environments' and their presence in nature and elsewhere are still open to debate.

Nowadays, individuals spend a lot of time far away from nature. Thus, they may have discovered other environments beside nature for recovery. Researchers claim that individuals also favor indoor environments with clear boundaries and privacy, or even crowded places to recover (Richter, 2008). Moreover, not all sensory impressions are equally important for the evaluation of an environment and its classification as perceived as restorative. Therefore, evaluation is based on crucial sensory impressions suggesting an order or hierarchy in the process of perception (Grahn & Stigsdotter, 2010). The aim of the current study is to identify restorative indoor and outdoor environments and their specific sensory qualities as well as dominant sensory impressions (in this paper called 'key elements'), following a multimodal sensory integration approach. The current study will contribute to designing restorative environments and provide cues for a restorative experience.

Which environments support restorative perceptions?

Two prominent theories describe recovery processes in natural environments: *Attention Restoration Theory* (*ART*; Kaplan, 1995) and *Stress Recovery Theory* (*SRT*, also called *Psycho-Evolutionary Theory*; Ulrich, 1983). Both theories state that natural environments support the restoration of depleted resources, but differ in the type of resources they investigate: cognitive resources in terms of directed attention (ART), and emotional resources in terms of arousal and valence (SRT).

According to the cognitive focus of ART, natural environments support restoration through indirect attention, meaning attention without effort (Berman et al., 2008; Kaplan & Kaplan, 1982; Kaplan & Berman, 2010). In contrast, SRT holds that positive affective reactions to natural environments, inscribed in our genetic make-up, facilitate stress recovery (Ulrich et al., 1991). Numerous studies tested both theories, and confirmed that distinct natural environments are suitable places to rebuild personal resources, and, in particular, to reduce physiological arousal (Beute & de Kort, 2014a/b; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Ulrich et al., 1991), to increase subjects' mood (Beute, & de Kort, 2014; Berman et. al, 2008; Hartig et al., 2003; Ulrich et al., 1991), and to improve cognitive functioning (Beute & de Kort, 2014 a/b; Berman et al., 2003; Hartig et al., 2003).

In industrial countries, many individuals work inside buildings (e.g., Urlaub, Hellwig, van Treeck, & Sedlbauer, 2010) and have no time to spend their breaks in outdoor natural environments (Depledge et al., 2011). Thus, some researchers also investigated indoor environments and their restorative potential. For example, Gulwadi (2006) pointed out that interpersonally stressed individuals like to recover at home and vocationally stressed individuals like to recover in natural environments. Moreover, Korpela and Hartig (1996) found that individuals mentioned both 'home' and 'greenery' when they were asked about preferred environments. Individuals do not even need to be in real natural environments to perceive the restorative effects. Simulations of nature also increase mood and improve cognitive functions––for instance, by exposing depleted persons to images or sounds of nature (Depledge et al., 2011; Hartig, Böök, Garvill, Olsson, & Gärling, 1996; Largo-Wight, 2011). Furthermore, even mental imaging of nature enhances positive affect (van Rompay & Jol, 2016). Therefore, imagination seems to be an adequate method for the prediction of recovery in real environments and will also be applied in the current study.

The present research assumes that specific urban elements might be as restorative as natural elements. This approach is based on the effect of processing fluency, which postulates that the experienced ease of processing a specific stimulus determines its pleasantness (Herrmann, Zidansek, Sprott & Spangenberg, 2013). Hence, stimuli that are fluently (easily) processed are typically evaluated as more pleasant. For instance, an environment which is fluently processed through visual and auditory input might be perceived as more pleasant than an environment which only induces pleasantness through visual input alone. The processing fluency approach is in line with 'person-environment fit' models, which postulate that a fit between ambient qualities and human needs fosters well-being (Sona & Steidle, 2016; Vischer, 2007). In this, it is assumed that easily processed environmental stimuli, whether natural or otherwise, can be perceived as pleasant or even restorative.

Exploring ambient qualities for restorative perceptions

Prior research has generally investigated restorative environments, with preference studies showing various photo slides focusing on visual stimuli. In contrast, in real environments individuals sense more than visual stimuli: in fact, they perceive a multisensory combination of various sensations, such as visual, auditory, and olfactory stimuli simultaneously, which builds a holistic impression.

Frontczak and Wargocki (2011) give an overview of research about multiple sensory parameters and their impact on overall comfort in indoor environments (see Fig. 1). They showed that different researchers postulated different impacts of distinct ambient qualities on overall comfort. Hence, a clear statement about the role of distinct ambient qualities for comfort and, eventually, for recovery is still lacking. Furthermore, a comprehensive quantitative survey was conducted by Grahn and Stigsdotter (2010; n = 953) who investigated various ambient qualities. They identified distinct elements of restorative environments and stated that "a combination of refuge, nature and rich in species, and a low or no presence of social, could be interpreted as the most restorative environment for stressed individuals" (p. 264). This description bears a great resemblance to personal homes and sheltered natural environments.

Normally, individuals have no time to perceive all of the sensations in an environment in detail before taking a decision or an action. Hence, their decisions and actions are based on a smaller number of dominant sensory impressions (key elements), suggesting an order or hierarchy in the process of perception (Grahn & Stigsdotter, 2010). This assumption suggests a global (instead of local) processing style to gain a first impression of the whole environment (Schooler, 2002). This hypothesis of global dominance was systematically investigated in Navon's (1977) letter task, showing large letters (e.g., one big 'H') written using small letters (e.g., many small 'L's). In this experiment, participants could identify the large letter, and thus the holistic impression, faster. This proves that analyzing the restorative qualities of an environment implies the identification of dominant ambient qualities (key elements) which significantly influence the holistic impression. The following section describes several physical qualities of an environment and explains why some of these elements may be more important for recovery than others.

As Grahn and Stigsdotter (2010) pointed out, the restorative potential of an environment is determined by its social as well as its physical context factors. Therefore, the current research will explore the presence of distinct physical elements and the presence of other individuals in restorative environments.

Lighting. The influence of light on physiological as well as psychological processes has been investigated in several studies. It is known that daylight regulates the human circadian rhythm (Werth, Steidle, Hubschneider, de Boer, & Sedlbauer, 2013). Moreover, Smolders and de Kort (2014) identified positive effects of bright light (1000 lux measured at the eye) on alertness, vitality and happiness in contrast to dimmed light (200 lux measured at the eye). *Thus, brightness and sunshine might represent crucial qualities for PRP* (see also Beute & de Kort, 2013).

Colors. Natural environments are perceived as restorative (Kaplan, 1995; Ulrich, 1983).

Thus, natural colors, e.g., green, blue or brown, should also be perceived as restorative. This assumption was confirmed by the research from Pretty, Peacock, Sellens and Griffin (2005) in their ’green gym’. They examined participants watching green scenes while walking on a treadmill. The green scenes fostered mental health and physical activity. Furthermore, Hipp, Gulwadi, Alves and Sequeira (2016) showed that greenness fosters perceived quality of life (see also Honold, Lakes, Beyer & van der Meer, 2016). *Hence, green should be an important aspect of restorative natural environments*. However, the context can change the meaning of colors and individual’s expectations and responses to certain colors (Elliot & Maier, 2012). For instance, ‘red’ is interpreted differently when used for a dress than for a traffic light or a wall color. *For this reason, different colors may elicit different restorative perceptions depending on the context.*

Sounds. Several studies demonstrated positive effects of natural sounds on recovery (e.g., bird sound or babbling water; Alvarsson, Wiens, & Nilsson, 2010; Ratcliffe et al., 2013). For example, Jahncke, Hygge, Green, & Dimberg (2011) pointed out that adding an auditory stimulus of river sounds while watching a nature video fostered recovery. Hereby, the integration of visual and auditory stimuli was experienced as more beneficial than only the visual impression. On the other hand, it has been repeatedly demonstrated that relaxing music (e.g., excerpts from Enya) compared to silence stopped the increase in salivary cortisol level after induced stress (Khalfa, Dalla Bella, Roy, Peretz, & Lupien, 2003). *Therefore, it is expected that natural sounds as well as relaxing music are beneficial for perceived restorative potential.*

Scents. The olfactory bulb is located next to the limbic system, where emotions and memories are processed (Bosmans, 2006; Krishna, 2012). Several studies showed the influence of pleasant (ambient) scents on positive mood (Baron, 1983, 1986, 1990; Herz, 2004; Michon, Chebat, & Turley, 2005; Spangenberg, Crowley, & Henderson, 1996). However, the identification of specific scents is rather difficult (Cleary, Konkel, Nomi, & McCabe, 2010). *Hence, it is assumed that pleasant scents are beneficial for PRP, even if individuals cannot* *identify the scent.*

Temperature. The perception of a pleasant temperature varies between individuals. However, individuals can adapt to thermal environments, e.g., by adjustment of clothing (Frontczak & Wargocki, 2011). *The current study outlines temperature preferences for PRP.*

Persons. Staats and Hartig (2004) indicated that while the presence of another person in urban environments is preferred more than being alone, this was not the case in natural environments. Moreover, Grahn and Stigsdotter (2010) discovered that stressed individuals prefer to be alone or with a only few persons to recover. On the other hand, Depledge et al. (2011) pointed out that the appeal of natural environments might be caused by "a liking for an environment with either few or no individuals, rather than for green space per se" (p.4660). *As a result, it is expected that no other persons or few persons are beneficial for PRP, particularly in natural environments.*

Research aims

An exploratory study is conducted with the aim of identifying indoor and outdoor environments with high PRP. The study investigates various environments that humans might prefer after cognitive or emotional depletion separately in order to determine different human needs for recovery depending on the type of depletion. To gain a deeper understanding of ambient qualities that are particularly beneficial for restorative perceptions, distinct ambient qualities (e.g., colors and scents) of environments are investigated. Moreover, in line with Navon's (1977) global processing style, this research aims to indicate key elements which significantly influence holistic impressions of an environment. For a presentation of the research aims, see Figure 2.

Methods

Subjects

265 German students (164 women; 101 men; mean age 21.09 years, *SD* = 2.95)

voluntarily participated in this study. All participants had good or very good knowledge of the German language. The study started in November 2013 and ran for two weeks.

Measures and Procedure

The survey contained open and closed questions. The questionnaire was divided into two parts that included questions about environments with PRP after cognitive depletion and emotional depletion (see Fig. 3; adapted from Ratcliffe et al., 2013, p.228). Furthermore, the questionnaire was divided into exploration of outdoor vs. indoor environments. Demographic questions about age and gender were asked, addressing one item each. To familiarize participants with the content of the survey and the question formats, the study started with open-ended warm-up questions asking participants to name and describe their favorite places (adapted from Ratcliffe et al., 2013). In addition, participants were asked why they preferred to go to those environments and what they did there. After the warm-up session, each participant answered questions concerning four different types of environments, in particular an

1) outdoor environment with PRP after a) cognitive depletion;

2) outdoor environment with PRP after b) emotional depletion;

3) indoor environment with PRP after a) cognitive depletion;

4) indoor environment with PRP after b) emotional depletion.

Participants were first requested to indicate their preferred indoor or outdoor environment after cognitive or emotional depletion. To investigate the PRP of an environment after cognitive depletion, participants were asked:

> *"Imagine you're exhausted after working hard on a task, and you're finding it hard to concentrate. Where would you go to restore your ability to concentrate?"-"Would you prefer to go to a natural environment (e.g,. park, garden, forest, beach) or to a specific room (e.g., café, cinema, bar, home)?"*

On the other hand, to investigate the PRP of an environment after emotional depletion, answers to the following questions were requested:

> *"Imagine that you are stressed and in a negative mood, perhaps after having an argument. Where would you go to relax? Would you prefer to go to a natural environment (e.g., park, garden, forest, beach) or to a specific room (e.g., café, cinema, bar, home)?"*

Afterwards, three open-ended questions were used to explore each of the four mentioned environments more precisely. The questions were presented in the following order:

> *"What does this environment look like? Can you describe it for me?"*
>
> *"What is relaxing about this place?"*
>
> *"What lighting conditions/colors/smells/sounds/persons/temperatures are here in this environment?"*

The first two open-ended questions were free recalls about the environment (see Fig. 3). The last open-ended question was an aided recall to specify the distinct ambient qualities of the mentioned environments. All open-ended questions permitted multiple answers per person. Then, one of two closed type questions were used to evaluate the specific restorative potential of each mentioned environmental quality on a Likert-scale (1: not at all – 7: very much). To investigate cognitive resources, the following question was used:

> "*Please rate on a scale from 'not at all' to 'very much' how much the mentioned aspects help you to restore your concentration." [lighting, colors, smells, sounds, persons, and temperature]*.

However, to investigate emotional resources the question was changed as follows:

> *"Please rate on a scale of 'not at all' to 'very much' how much the mentioned aspects help you to relax." [lighting, colors, smells, sounds, persons, and temperature]*.

Additionally, a global indicator of PRP was assessed with the following question:

> *"We would like to ask you to give a global statement about the restorative potential of the environment on a scale from 0% to 100%."*

Data Analysis

The open-ended questions included specific descriptions of an environment. The area of interest of the current study was to identify general statements about individual's preferred environments for restoration. Therefore, two independent researchers conducted a content analysis (Elo & Knygas, 2008). First, participants' answers were transformed into code names based on words which were most frequently mentioned (Irvine, Warber, Devine-Wright & Gaston, 2013). Second, the answers were sorted into outdoor vs. indoor environments. Moreover, the codes were clustered into different ambient qualities (lighting, colors, smells, sounds, individuals, and temperature). Finally, the different ambient qualities were grouped into subcategories, e.g., color was grouped into green, red, yellow, etc. (Sester, Dacremont, Deroy & Valentin, 2013).

When participants mentioned several aspects from one category (e.g., two colors), the first aspect mentioned was coded first, then the second aspect mentioned, and so on. Some participants simply named a generic term as their preferred environment for restoration (e.g., 'nature') without concrete specification of the kind of environment they were actually thinking of. In contrast, other participants gave a detailed description of the specific environment. Since the current study was interested in descriptions that were as accurate as possible, participants who gave a more concrete answer than a simple generic term were not aggregated into the generic term (e.g., the naming of 'park' was analyzed separately from the generic term of 'nature').

For further statistical analyses, two independent researchers converted the code names into dummy variables (1 = item stated; 0 = item not stated). Afterwards, Cohen's Kappa was calculated to define inter-rater agreements (Wirtz & Caspar, 2002). The following results comprise analyses with Cohen's Kappa ≥ .60 (adapted from Landis & Koch, 1977; for an overview of Cohen's Kappa see supplemental material, Table S1a-e).

Data collection, containing open-ended and closed-type questions, followed a mixed-method approach to investigate a single construct, namely the restorative potential of an environment. This approach was chosen to increase the validity of the measurement (Delle Fave, Brdar, Freire, Vella-Brodrick, & Wissing, 2011). Figures 4a and 4b represent all outdoor and indoor environments which were mentioned by participants. The current analyses concentrate on the most frequently mentioned environments, i.e., at least 10% of participants should have mentioned the specific environment (for 10% level see dotted lines in Fig. 4a and Fig. 4b; procedure adapted from Sester et al., 2013). From these mentioned specific environments, ambient qualities (e.g., colors, lighting, etc.) were analyzed further if they had been mentioned by more than 25% of participants (see grey marked areas in Table 1a and Table 1b).[1]

Frequency analyses and a chi-square test were performed to examine the differences throughout the participants' responses concerning outdoor and indoor environments with perceived restorative potential (PRP) after cognitive vs. emotional depletion. Moreover, the closed-type questions were tested with variance analyses to investigate the impact of outdoor and indoor environments as well as distinct ambient qualities of these environments for PRP.

Results

Frequency analyses

Frequency analyses of preference for outdoor and indoor environments revealed that after cognitive depletion 47.2% of participants preferred outdoor environments (e.g., park/garden or

[1] Note that the results of the second open-ended question are not part of this article, since the ambient qualities named by free recall were quite similar to the answers of the third question by aided recall, but showed less detail.

nature), whereas 38.5% of participants preferred indoor environments (e.g., café, home). 13.2% of participants had no preference (see Fig. 5), and 1.1% would go to neither a specific outdoor nor a specific indoor environment. On the other hand, for PRP after emotional depletion 35.5% of participants preferred outdoor environments (e.g., park/garden or nature), whereas 41.9% preferred indoor environments (e.g., café, home). 17.7% of participants had no preference, and 4.9% would go to neither a specific outdoor nor a specific indoor environment (see Fig. 5). The chi-square test indicated that the frequency of preferences for outdoor vs. indoor environments were significantly different depending on the type of depletion, χ^2 (1, n = 182) = 7.72, $p < .01$, $\phi = .21$. For PRP after cognitive depletion, participants preferred outdoor environments, whereas for PRP after emotional depletion, they preferred indoor environments.

Outdoor environments with PRP after cognitive depletion.[2] When asked for an outdoor environment with PRP after cognitive depletion, 84 participants (31.7%) named ‘park’ or ‘garden.’ 70 participants (26.4%) named ‘edge of the forest,’ 59 participants (22.3%) named ‘nature,’ 45 participants (17%) named ‘fields’ or ‘meadows,’ and 32 participants (12.1%) named ‘sea,’ ‘beach,’ ‘lake,’ or ‘water’ (see Fig. 4a, blue bars). On the ***global indicator*** of restorative potential, ‘park/garden’ received a mean value of 75.42 (*SD* = 19.44), ‘edge of the forest’ a mean value of 85.31 (*SD* = 13.65), ‘nature’ a mean value of 80.59 (*SD* = 21.12), ‘fields/meadows’ a mean value of 83.21 (*SD* = 16.59), and ‘sea/beach/lake/water’ a mean value of 75.97 (*SD* = 26.05). Table 1a and 1b contain ambient qualities referred by participants in the frequently stated outdoor environments. In these five outdoor environments, participants frequently (more than 25%) mentioned ‘bright’ and ‘sunny’ lighting conditions and the colors ‘green’ and/or ‘blue’ as visual elements of the scenes. Furthermore, participants preferred the sound of ‘birdsong’ and ‘to be alone’ in all five outdoor environments.

[2] Correlations between the mentioned ambient qualities and global indicators of restoration were tested, but did not yield more insights for predicting specific associations (see Table S4a). Note that participants could mention more than one environment (e.g., ‘I go into nature. I love to walk in this field next to my place’).

In addition to these general qualities of restorative outdoor environments, ‘park/garden’ was described as colorful and mild in temperature (21 to 25 °C). The descriptions of ‘edge of the forest’ included the color ‘brown,’ rather cool temperatures between ‘16 to 20 °C’ or temperatures ‘dependent on the season,’ and the presence of only a ‘few persons.’ Describing ‘nature,’ participants additionally referenced the color ‘brown’, and temperatures between’ 21 to 25 °C’. Describing ‘fields/meadows,’ participants additionally named the color ‘brown,’ the sound of ‘wind,’ and the presence of only a ‘few persons.’ Participants describing ‘sea/beach/lake/water’ further mentioned the color ‘yellow,’ ‘smells of the sea,’ the presence of only a ‘few persons,’ and mild temperatures between ‘21 to 25 °C.’

Outdoor environments with PRP after emotional depletion. Asked for an outdoor environment with PRP after emotional depletion, 64 participants (24.2%) named ‘park’ or ‘garden,’ 53 participants (20.0%) named ‘edge of the forest,’ 38 participants (14.3%) named ‘nature,’ 42 participants (15.8%) named ‘fields’ or ‘meadows,’ and a further 36 participants (13.6%) named ‘sea’ or ‘beach’ or ‘lake’ or ‘water’ (see Fig. 4a, grey bars). On the *global indicator* of restorative potential, ‘park/ garden’ received a mean value of 77.05 (SD = 11.96), ‘edge of the forest’ a mean value of 78.67 (SD = 16.68), ‘nature’ a mean value of 78.72 (SD = 13.76), ‘fields/meadows’ a mean value of 76.25 (SD = 18.39), and ‘sea/beach/lake/water’ a mean value of 85.28 (SD = 11.76). Again, participants frequently mentioned ‘bright’ and ‘sunny’ lighting conditions and the color ‘green’ as visual elements in all five sceneries (see Table 1a and 1b). ‘Being alone’ was part of four of the five scenery descriptions (all sceneries except ‘sea/beach/lake/water’).

In addition to these general qualities, ‘park/garden’ frequently included the color ‘brown’ and a ‘colorful’ impression, and mild temperatures between ‘21 to 25 °C.’ Describing ‘edge of the forest,’ participants additionally named the color ‘brown,’ the sound of ‘whispering trees,’ and rather cool temperatures between ‘16 to 20 °C.’ Describing ‘nature,’ participants additionally included the colors ‘blue’ and ‘brown.’ Describing ‘fields/meadows,’ participants additionally named the colors ‘blue’ and ‘brown,’ and mild temperatures between ‘21 to 25 °C.’ Participants describing ‘sea/beach/lake/water’ further named the colors ‘yellow’ and ‘blue,’ ‘smells of the sea,’ the sound of ‘babbling water,’ and warm temperatures between ‘26 to more than 30 °C.’

Indoor environments with PRP after cognitive depletion. Asked for an indoor environment with PRP after cognitive depletion, 116 participants (44.11%) named some kind of a *home environment*: 56 participants (21.1%) named ‘home,’ 18 participants (6.8%) named ‘living room,’ and 42 participants (15.8%) named ‘my room.’ Moreover, 36 participants (13.6 %) noted ‘café’ as their favorite place for indoor restoration (see Fig. 4b, blue bars). On the *global indicator* of restorative potential, ‘home’ received a mean value of 80.07 (SD=18.52), ‘living room’ a mean value of 73.07 (*SD* = 23.98), ‘my room’ a mean value of 71.74 (*SD* = 29.67), and ‘café’ a mean value of 77.19 (*SD* = 15.65).

Table 2a and 2b contain ambient qualities referenced by participants in three frequently mentioned indoor environments ‘home,’ ‘my room,’ and ‘café’. Additionally, ’living room’ is reported since it is a kind of home environment. The descriptions of the four indoor environments contain bright and sunny lighting and the colors ‘white’ and ‘brown’ as visual features, temperatures between ‘21 to 25 °C,’ and the preference of ‘being alone.’

In addition to these general qualities, descriptions of home environments frequently included either ‘silence’ or ‘music/singing,’ and the presence of ‘no or one other person.’ Descriptions for living rooms additionally contained the color ‘black,’ ‘silence,’ ‘being alone,’ and rather cool temperatures between ‘16 to 21 °C.’ Participants mentioning their ‘own room’ additionally referred to the color ‘red,’ ‘no sound/ silence,’ ‘being alone’ or ‘with only one other person,’ and rather cool temperatures between ‘16 to 20 °C.’ Descriptions for ‘cafés’ frequently included the color ‘red,’ the ‘smell of coffee’ as well as ‘freshly-baked bread/cake,’ ‘music/singing’ or ‘voices,’ and ‘being alone.’ Apparently, the more specific categories of ‘my room,’ ‘living room,’ and ‘café’ possess more unique qualities compared to the broader category of ‘home.’

Indoor environments with PRP after emotional depletion. Asked for an indoor environment with PRP after emotional depletion, 113 participants (42.7%) declared some kind of a *home environment*: 44 participants (16.6%) named ‘home,’ 15 participants (5.7%) named ‘living room,’ and 54 participants (20.4%) named ‘my room.’ ‘Living room’ will be reported separately from ‘home’ and ‘my room,’ since it is a room at home but different from the bedroom. Moreover, 31 participants (11.7%) referred to ‘café’ as their favorite place for indoor restoration (see Fig. 4b, grey bars). On the *global indicator* of restorative potential, ‘home’ received a mean value of 75.10 (SD = 23.24), ‘living room’ a mean value of 74.08 (SD = 12.69), ‘my room’ a mean value of 69.33 (SD = 17.69), and ‘café’ a mean value of 63.53 (SD = 25.82).[2] The different home environments (‘home,’ ‘my room,’ and ‘living room’) were apparently perceived as more restorative than ‘café.’

In all four indoor environments, participants frequently named ‘bright’ and ‘sunny’ lighting conditions, the colors ‘white’ and ‘brown,’ and temperatures between ‘21 to 25 °C’ (see Table 2a and 2b). In addition to these general qualities, descriptions of ‘home’ environments frequently included either ‘silence’ or ‘music/singing,’ the presence of ‘no one to two other persons,’ and rather cool temperatures between ‘16 to 20 °C.’ Descriptions of ‘living room’ contained the color ‘green’ and ‘silence’ as well as ‘voices’ and ‘being alone.’ Participants describing their ‘own room’ additionally mentioned ‘no sound/silence,’ ‘being alone’ or with only ‘one other person,’ and rather cool temperatures between ‘16 to 20 °C.’ In contrast, descriptions of ‘café’ frequently included also ‘dim lighting,’ the ‘smell of coffee,’ ‘music/singing’ or ‘voices,’ and the presence of ‘many individuals.’ Obviously, the more specific categories of ‘my room,’ ‘living room,’ and ‘café’ possess more unique qualities than the broader category of ‘home.’

Variance analyses

To determine the relative importance of different ambient qualities for the perceived restorative potential of indoor and outdoor environments after cognitive or emotional depletion, a 2 (type of depletion: cognitive vs. emotional) x 2 (environment: outdoor vs. indoor) x 6 (ambient quality) ANOVA with repeated measurements was conducted (for means and standard deviations see Table S2). The ANOVA revealed a main effect of environment, $F(1, 261) = 42.66$, $p < .01$, $\eta^2 = .14$, and a main effect of environmental quality, $F(5, 1305) = 39.32$, $p < .01$, $\eta^2 = .13$. In line with results of previous preference analyses, paired comparisons using Bonferroni correction revealed that outdoor environments ($M = 4.68$, $SD = .05$) were perceived as higher in restorative potential than indoor environments ($M = 4.42$, $SD = .05$).

Regarding the relative importance of each environmental quality, paired comparisons revealed that lighting ($M = 5.02$, $SD = .07$) was perceived as more important than all other qualities (all *p's* $< .01$; for means and standard deviations, see Table S2). Moreover, sounds ($M = 4.66$, $SD = .07$) were perceived as more important than colors ($M = 4.40$, $SD = .07$; $p < .05$), and scents ($M = 3.96$, $SD = .08$) were perceived as less important than all other ambient qualities (*p's* $< .01$). No other effects were significant.

Furthermore, the ANOVA yielded a significant interaction of environment x ambient quality, $F(5, 1305) = 6.52$, $p < .01$, $\eta^2 = .02$ and a significant interaction of type of depletion x environmental quality, $F(5, 1305) = 2.54$, $p < .05$, $\eta^2 = .01$. Paired comparisons using Bonferroni correction revealed that lighting, colors, sounds, and scents were perceived as more important for restorative perceptions in outdoor environments than in indoor environments (all *p's* $< .05$; for means and standard deviations see Table S3a). For temperature and amount of persons, there were no significant differences between outdoor and indoor environments. Moreover, colors, sounds, and scents were assessed as more important for creating a restorative perception in outdoor compared to indoor environments (all *p's* $< .05$).

Further paired comparisons pointed out that lighting was marginally more important after cognitive than emotional depletion ($p < .10$), whereas the reverse applied for acoustic stimuli ($p < .10$; for means and standard deviations, see Table S3b). No other effects were significant. Overall, the relative importance of different ambient qualities for the perceived restorative potential of an environment partly differs between indoor and outdoor environments and situations of emotional or cognitive depletion.

Discussion

The aim of the current study was to identify indoor and outdoor environments which are perceived as restorative after cognitive or emotional depletion. Further, the study aimed to identify distinct ambient qualities of these environments and explore key elements which significantly influence the holistic impression of the environment.

On a global level, variance analyses indicated that outdoor environments were perceived as more important for recovery perception than indoor environments. The identified environments are in line with previous research about restorative environments (e.g., Berman et al., 2008; Beute, & de Kort, 2014a/b; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Kaplan & Kaplan, 1982; Kaplan & Berman, 2010; Korpela & Hartig, 1996; Ulrich et al., 1991). More precisely, results showed that individuals preferred outdoor environments after cognitive depletion and indoor environments after emotional depletion. Thus, the current study replicates the findings from Gulwadi et al. (2006), indicating variations in environmental preferences depending on the type of depletion. The preference for outdoor environments to recover from cognitive depletion corresponds to ART (Kaplan & Kaplan, 1982). However, the findings remain in contrast to SRT (Ulrich, 1983), assuming that humans also prefer nature after emotional depletion. Hence, the current research contributes to theory building of restorative environments: The preferred environment to recover from emotional depletion is an indoor environment. These results also reflect former research (Gulwadi, 2006) and indicate the necessity to differentiate which environments are suitable for what kind of recovery.

Moreover, the global indicator of restorative potential indicated that all three home environments received higher scores than cafés after emotional depletion. This might hint at the availability heuristic, postulating that more familiar places (here: own home) are evaluated as more positive (Werth, 2009).

Concerning ambient qualities within these specific environments, frequency analyses showed no major differences between the environments that individuals might prefer after cognitive or emotional depletion (see Table 1a/ 1b and Table 2a/ 2b). Instead, the reported ambient qualities varied between indoor and outdoor environments in general, and between the described sceneries in particular. Nevertheless, various key elements could be identified, which formed part of many environments with restorative potential. First, since 'bright/sunny' lighting was mentioned in all outdoor and indoor environments, regardless of the type of depletion (cognitive vs. emotional), it is concluded that *bright/sunny lighting represents a key element* which influences the holistic impression of restorative environments. Variance analyses supported this assumption, showing that the lighting types mentioned were evaluated as more helpful for restorative perceptions than all other sensory impressions. The results are consistent with previous research about the positive effects of bright light on alertness, vitality, and happiness (Smolders & de Kort, 2014).

Second, the color green was mentioned in all outdoor environments, regardless of the type of depletion. Hence, it can be concluded that *the color green is a key element for recovery* in outdoor environments. This result is in line with variance analyses indicating that colors were more helpful for restorative perceptions in outdoor than in indoor environments.

Third, in four out of five outdoor environments, the colors blue and brown were named as crucial qualities of restorative environments. Further, since the colors brown and white were mentioned in all indoor environments, it can be noted that *the colors brown and white are key elements for recovery in indoor environments.* The colors green, blue and brown are often found in nature. Thus, the results reflect previous research emphasizing that nature, and thereby natural colors, are important for recovery (Kaplan, 1995; Ulrich, 1983). The color white can also be interpreted as a natural color, since clouds, and thus the sky, are often perceived as white.

Fourth, only a few participants explicitly mentioned an ambient scent in outdoor and indoor environments. Moreover, variance analyses showed that scents were evaluated as less helpful for restorative perceptions than all other sensory impressions. These results correspond with previous research postulating that individuals often recognize an odor, but its identification is rather difficult (Cleary et al., 2010).

Fifth, for eight out of nine of the restorative outdoor environments described, *birdsong* represented a crucial quality for PRP regardless of the type of depletion. This result is in line with previous research showing positive effects of chirping birds on recovery (Alvarsson et al., 2010; Ratcliffe et al., 2013). Moreover, for six out of eight indoor environments, regardless of the type of depletion, individuals preferred *no sound/silence*, and for eight out of nine outdoor and indoor environments, *individuals preferred to be alone*. This result corresponds with the research of Grahn and Stigsdotter (2010) showing that for recovery, stressed individuals prefer the presence of no other person or a few persons.

Sixth, for outdoor environments, preferences for specific temperatures were not clear regardless of the type of depletion. Thus, the temperature seems to be less important for the sense of recovery in outdoor environments. These results are in line with the studies of Xu and Labroo (2014) showing that individuals' perception of temperature was influenced through a different sensory input, namely ambient brightness. In contrast, for indoor environments there was a preferred temperature in all environments mentioned, namely 21-25 °C— regardless of the type of depletion. Therefore, it is concluded that *temperatures between 21-25 °C are a key element for recovery in indoor environments*.

To sum up, the study identified two key elements for fostering recovery in *outdoor environments*, namely (1) *bright/sunny lighting* and (2) *the color green*. Moreover, birdsong and no other persons present/being alone seem to be crucial elements, but are not as distinct as the two key elements. In addition, the study identified four key elements for fostering recovery in *indoor environments,* namely (1) *bright/sunny lighting,* (2) *21-25 °C,* (3) *the color white,* and (4) *the color brown.* Further, no sound/silence and no other persons present/being alone seem to be crucial elements, but are not as distinct as the four key elements.

Implications and strengths of the current research

The results of the study lead to the following implications. First, the study identified five specific outdoor and four specific indoor environments for recovery perceptions. The strength of the identified environments is the degree of detail with which they are described. Therefore, the study provides precise information about various ambient qualities for each environment separately and about their impact after cognitive and emotional depletion.

Second, the current study identified several key elements, indicating that some elements are more beneficial for restorative perceptions than others (adapted from global processing style, Navon, 1977). These key elements seem to be beneficial for any outdoor vs. indoor environment. Therefore, the present study takes up the assumption of Grahn and Stigsdotter (2010) postulating that individual's decisions and actions in an environment are based on some dominant impressions, suggesting an order or hierarchy in the process of perception.

Third, since not every ambient quality of the mentioned environments is perceived as highly important for the perception of a highly restorative environment, it is concluded that individuals might compensate for the absence (or less restorative impact) of some elements (e.g., scents) if other more important elements are present (e.g., lighting).

Fourth, the current research aims to generalize insights into the perception of restorative environments and draw general conclusions. In contrast, in former explorative studies comments of participants were not coded and categorized; instead, individual statements were presented (e.g., Milligan & Bingley, 2007; Ratcliffe et al., 2013). Despite the value of the individual cases for insights and theory development, restoration research also needs to outline general recommendations in order to facilitate designing break environments which are typically preferred by more than one person.

Fifth, in contrast to the research of Frontczak and Wargocki (2011), the present study found a different pattern regarding the influence of specific ambient qualities on the perceived restorative potential of different environments (compare Fig. 1 and Fig. 6). While Frontczak and Wargocki (2011) presented a relatively wide span of perceived comfort for several ambient qualities (e.g., scores of temperature between 1 and 4), the current data show a relatively homogeneous picture, indicating that all ambient qualities are evaluated as almost equally important. The different results may stem from mixed methods of data collection in the various studies referenced by Frontczak and Wargocki (2011). In contrast, the current study allows direct comparisons to be made of the impact of distinct ambient qualities on PRP, since the assessment of all ambient qualities was collected within one large dataset using the same method.

Limitations and future research questions

Despite the insights presented, at least four questions remain to be answered by future research. First, the present research did not investigate the sense of touch within the mentioned environments. Touch is the first sense humans develop and the last they lose in their old age (Krishna, 2012). The sense of touch influences aspects such as consumer behavior (Krishna, 2012). Moreover, many individuals enjoy relaxing massages, which represent a haptic experience. Thus, the question remains open as to whether tactile impressions influence recovery perceptions.

Second, the current research does not take into account different ‘styles’ of restorative perception. The assumption is based on education research postulating different learning styles (visual, auditory, and kinesthetic; e.g., Ren, 2013). In line with this assumption, different styles (or preferences) of restorative perception (e.g., visual, acoustic, olfactory, or tactile) might exist. For instance, acoustically oriented participants might be able to name more auditory impressions within an environment than visually oriented participants. Hence, future studies might complement the preferred style of restorative perception as a moderator variable in the research model.

Third, the participants of this study were German students. It remains to be clarified whether individuals with different cultural backgrounds and age spans would mention the same environments and ambient qualities. Despite this, however, the present study can be used to provide methodological orientation. Fourth, the present study used an imagery technique asking participants *to imagine* that they are exhausted or stressed and asking them to imagine where they would like to go to restore. Thus, the study measured the imagination of recovery, but not the recovery itself. This fact includes bias from subjective representations and memories, which should be minimized in future research. However, studies showed that the neural network which is activated while imaging a motion (or pain) overlaps with the neural network which is activated when actually performing this action (or feeling this pain; Decety & Grèzes, 2006). Hence, the predictive power of imagination of recovery for real recovery behavior should not be underestimated.

Practical implications of the current research

The present research contains practical implications for the selection or design of outdoor and indoor environments, such as break areas. The identified key elements could be understood as design recommendations. For instance, on the basis of the current data, it is recommended to build outdoor environments with bright light, the sound of birdsong, the color green and the absence of other persons. In contrast, for indoor environments, it appears to be beneficial to use bright light, the colors brown and white, and no sound, and to offer surroundings without the presence of any other person. Moreover, it is recommended to offer outdoor environments after cognitive depletion, whereas it is recommended to offer indoor environments after emotional depletion.

The current research also contributes to the creation of restorative virtual realities. So far, research addressing integration of various ambient qualities such as vision, smell, thermal conditions, and sound, has been relatively sparse, revealing the importance of the current research (Depledge et al., 2011).

Conclusion

The current research gives important insights into the perceived restorative potential of outdoor and indoor environments and their ambient qualities. The results indicate that individuals prefer different environments depending on the type of depletion (cognitive vs. emotional), and highlights the special role of key elements. In contrast to former studies, this research presents general conclusions providing useful cues for designing evidence-based restorative environments which are preferred by many individuals.

References

Alvarsson, J.J., Wiens, S., & Nilsson, M.E. (2010). Stress recovery during exposure to nature sound and environmental noise. *International Journal of Environmental Research and Public Health, 7*(3), 1036–1046. doi:10.3390/ijerph7031036

Berman, M.G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. Psychological Science, 19(12), 1207–1212. doi:10.1111/j.1467-9280.2008.02225.x

Beute, F., & de Kort, Y.A.W. (2013). Let the sun shine! Measuring explicit and implicit preference for environments differing in naturalness, weather type and brightness, *Journal of Environmental Psychology, 36*, 162-187.

Beute, F., & de Kort, Y.A.W. (2014a). Natural resistance: Exposure to nature and self-regulation, mood, and physiology after ego-depletion. *Journal of Environmental Psychology, 40,* 167–178. doi:10.1016/j.jenvp.2014.06.004

Beute, F., & de Kort, Y.A.W. (2014b). Salutogenic effects of the environment: Review of health protective effects of nature and daylight. *Applied Psychology: Health and Well-Being, 6*(1), 67–95. doi:10.1111/aphw.12019

Decety, J., & Grèzes, J. (2006). The power of simulation: Imagining one's own and other's behaviour. *Brain Research, 1079*(1), 4-14, doi: 10.1016/j.brainres.2005.12.115

Delle Fave, A., Brdar, I., Freire, T., Vella-Brodrick, D., & Wissing, M.P. (2011). The eudaimonic and hedonic components of happiness: Qualitative and quantitative findings. *Social Indicators Research, 100*(2), 185-207.

Cleary, A. M., Konkel, K. E., Nomi, J. S., & McCabe, D. P. (2010). Odor recognition without identification. *Memory & Cognition, 38,* 452–460.

Depledge, M. H., Stone, R. J., & Bird, W., J. (2011). Can natural and virtual environments be used to promote improved human health and wellbeing? *Environmental Science & Technology, 45,* 4660–4665. doi: 10.1021/es103907m

Irvine, K.N., Warber, S.L.,Devine-Wright, P.,& Gaston, K.J. (2013). Understanding urban green space as a health resource: A qualitative comparison of visit motivation and derived effects among park users in sheffield, UK. *International Journal of Environmental Research and Public Health, 10,* 417-442. doi:10.3390/ijerph10010417

Eggleston, P.A (2007). The environment and asthma in US inner cities. *Chest, 132*, 782S–788S.

Elliot, A. J. & Maier, M. A. (2012). Color-in-context theory. In: Plant, A., Devine, P.: *Advances in Experimental Social Psychology*, *45,* 61-125. doi: 10.1016/B978-0-12-394286-9.00002-0

Elo, S., & Kyngas, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing, 62*, 107–115.

Flegal, K.M.; Carroll, M.D.; Ogden, C.L.; Curtin, L.R. (2010). Prevalence and trends in obesity among US adults, 1999–2008. *JAMA, 303*, 235–241.

Friedman, B., Freier, N.G., Kahn Jr., P.H., Lin, P., & Sodeman, R. (2008). Office window of the future?—Field-based analyses of a new use of a large display. *International Journal of Human-Computer Studies, 66*(6), 452–465. doi:10.1016/j.ijhcs.2007.12.005

Frontczak, M., & Wargocki, P. (2011). Literature survey on how different factors influence human comfort in indoor environments. *Building and Environment, 46*, 922-937.

Grahn, P. & Stigsdotter, U.K. (2010). The relation between perceived sensory dimensions of urban green space and stress restoration. *Landscape and Urban Planning, 94*, 264–275. doi:10.1016/j.landurbplan.2009.10.012

Gulwadi, G. B. (2006). Seeking restorative experiences: elementary school teachers' choices for places that enable coping with stress. *Environment & Behavior, 38,* 503–520. doi: 10.1177/0013916505283420

Hartig, T., Böök, A., Garvill, J., Olsson, T., & Gärling, T. (1996). Environmental influences on psychological restoration. *Scandinavian Journal of Psychology, 37*(4), 378–393.

doi:10.1111/j.1467-9450.1996.tb00670.x

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology, 23*(2), 109–123. doi:10.1016/S0272-4944(02)00109-3

Herrmann, A., Zidansek, M., Sprott, D. E., & Spangenberg, E. R. (2013). The power of simplicity: Processing fluency and the effects of olfactory cues on retail sales, *Journal of Retailing, 89*(1), 30-43. doi: 10.1016/j.jretai.2012.08.002

Hipp, A. J., Gulwadi, G. B., Alves, S., & Sequeira, S. (2016). The relationship between perceived greenness and perceived restorativeness of university campuses and student-reported quality of life. *Environment and Behavior, 48*(10), 1292–1308. doi: 0.1177/0013916515598200

Honold, J., Lakes, T., Beyer, R. & van der Meer, Ek. (2016). Restoration in Urban Spaces: Nature Views From Home, Greenways, and Public Parks. *Environment and Behavior, 8*(6) 796 –825. doi: 0.1177/001391651456855

Jahncke, H., Hygge, S., Halin, N., Green, A.M., & Dimberg, K. (2011). Open-plan office noise: Cognitive performance and restoration. Journal of Environmental Psychology, 31(4), 373–382. doi:10.1016/j.jenvp.2011.07.002

Joye, Y. (2007). Architectural lessons from environmental psychology: the case of biophilic architecture. *Review of general psychology, 11*, 305-328.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. New York: Cambridge University Press.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15*(3), 169–182. doi:10.1016/0272-4944(95)90001-2

Kaplan, S., 2001. Meditation, restoration, and the management of mental fatigue. *Environmental Behavior, 33*, 480–506.

Kaplan, S., & Berman, M.G. (2010). Directed attention as a common resource for executive functioning and self-regulation. *Perspectives on Psychological Science, 5*(1), 43–57. doi:10.1177/1745691609356784

Khalfa, S., Dalla Bella, S., Roy, M., Peretz, I., & Lupien, S. J. (2003). Effects of relaxing music on salivary cortisol level after psychological stress. *Annals of the New York Academy of Sciences,* 999, 374–76.

Kline, G. A. (2009). Does A View of Nature Promote Relief From Acute Pain. *Journal of Holistic Nursing*, *27*(3), 159-166.

Krishna, A. (2012). An integrative review of sensory marketing: Engaging the senses to affect perception, judgment and behavior. *Journal of Consumer Psychology, 22*(3), 332–351. doi:10.1016/j.jcps.2011.08.003

Kruger, H. S.,Venter, C.S., & Vorster, H.H. (2003). Physical inactivity as a risk factor for cardiovascular disease in communities undergoing rural to urban transition: The THUSA study. *Cardiovascular Journal of South Africa, 14*, 16–23.

Landis, J.R., & Koch G.G. (1977). The measurement of observer agreement for categorical data, *Biometrics,* 33, 159–174.

Largo-Wight, E. (2011). Cultivating healthy places and communities: evidenced-based nature contact recommendations. *International Journal of Environmental Health Research, 21,* 41-61.

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. Cognitive Psychology, 9, 353–383. doi:10.1016/0010-0285(77)90012-3

Pretty, J., Peacock, J., Sellens, M., Griffin, M. (2005). The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research, 15,* 319–337.

Ratcliffe, E., Gatersleben, B. and Sowden, P.T. (2013). *Bird sounds and their contributions to perceived attention restoration and stress recovery, Journal of Environmental Psychology*, 36, 221-228.

Ren, G. (2013). Which learning style is most effective in learning chinese as a second language. *Journal of International Education Research, 9*(1), 21-32.

Richter, P. G. (2008). *Architekturpsychologie: Eine Einführung.* Lengerich: Pabst Science Publishers.

Schooler, J.W. (2002). Verbalization produces a transfer inappropriate processing shift. *Applied Cognitive Psychology*, *16*, 989–997. doi: 10.1002/acp.930

Sester, C., Dacremont, C.,Deroy, O., & Valentin, D. (2013). Investigating consumers' representations of beers through a free association task: A comparison between packaging and blind conditions. *Food Quality and Preference, 28,* 475-483. doi: 10.1016/j.foodqual.2012.11.005

Smolders, K.C., & de Kort, Y.A.W. (2014). Bright light and mental fatigue: Effects on alertness, vitality, performance and physiological arousal. *Journal of Environmental Psychology*, *39,* 77-91. doi:10.1016/j.jenvp.2013.12.010

Sona, B. & Steidle, A. (2016). Resilienz stärken: Die Gestaltung von Erholungswelten in Pausenräumen. *Technische Sicherheit*, *36*(3), 28-32.

Staats, H., & Hartig, T. (2004). Alone or with a friend: A social context for psychological restoration and environmental preferences. *Journal of Environmental Psychology, 24*(2), 199–211. doi:10.1016/j.jenvp.2003.12.005

Van Rompay, & Jol, T. (2016). Wild and free: Unpredictability and spaciousness as predictors of creative performance, *Journal of Environmental Psychology*, *48*, 140-148. doi: 10.1016/j.jenvp.2016.10.001

Ulrich, R. S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*(3), 201–230. doi:10.1016/S0272-4944(05)80184-7

Ulrich, R.S. (1983). Aesthetic and affective response to natural environment. In I. Altman & J. F. Wohlwill (Eds.), *Behavior and the Natural Environment* (pp. 85–125). Plenum

Press, New York.

Urlaub, S., Hellwig, R.T., van Treeck, C., & Sedlbauer, K. (2010). Möglichkeiten und Grenzen bei der Modellierung von Einflussfaktoren auf die menschliche Leistungsfähigkeit [Possibilities and limitations of modelling factors influencing human performance]. *Bauphysik, 32*(6), 373-379.

Vischer, J. C. (2007). The effects of the physical environment on job performance: towards a theoretical model of workspace stress. *Stress and Health, 23*(3), 175–184. doi:10.1002/smi.1134

Werth, L. (2009). Psychologie für die Wirtschaft. Grundlagen und Anwendungen. Heidelberg: Spektrum Akademischer Verlag.

Werth, L., Steidle, A., Hubschneider, C., de Boer, J., Sedlbauer, K. (2013. Psychologische Befunde zu Licht und seiner Wirkung auf den Menschen - ein Überblick. *Bauphysik, 35*, 193-204.

Wirtz, M. & Caspar, F. (2002). Beurteilerübereinstimmung und Beurteilerreliabilität: Methoden zur Bestimmung und Verbesserung der Zuverlässigkeit von Einschätzungen mittels Kategoriensystemen und Ratingskalen. Göttingen: Hogrefe.

Xu, A.J., & Labroo, A. (2014). Incandescent affect: Turning on the hot emotional system with bright light. *Journal of Consumer Psychology, 24*(2), 207 – 216. doi: 10.1016/j.jcps.2013.12.007

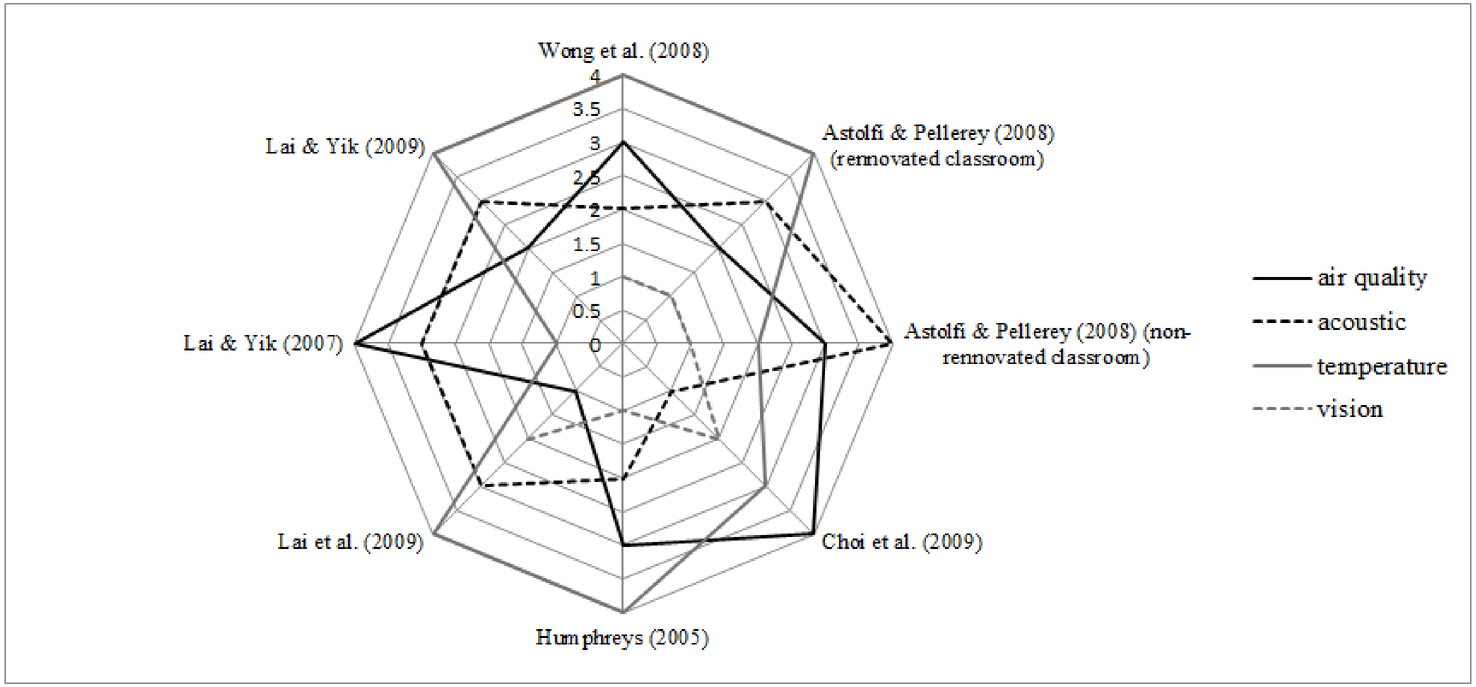


Fig. 1. Different sensory parameters and their impact on overall comfort of indoor environments. *Note.* Higher numbers indicate higher importance for indoor comfort (adapted from Frontczak & Wargocki, 2011).

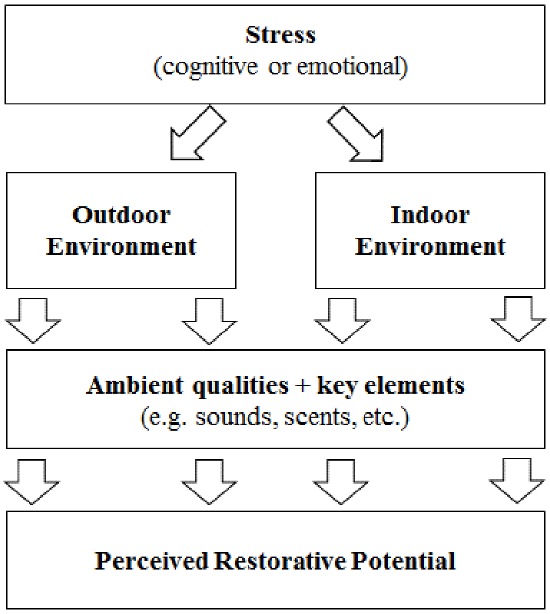


Fig. 2. Depiction of research aims.

<u>Open-ended questions</u>

1. "Imagine, you're **exhausted [stressed and in a negative mood]** after **working hard on a task [having an argument], and you find it hard to concentrate.**
   "Where would you go in order to **restore your ability to concentrate [relax]**?" Would you prefer to go to a natural environment (e.g. park, garden, forest, beach) or to a specific room (e.g. café, cinema, bar, home)?"
2. "What does this environment looks like? Can you describe it for me?"
3. "What is relaxing about this place? What lighting conditions/ colors/ smells/ soundss/ persons/ temperatures are here in this environment?"

<u>Closed questions</u>

1. "Please rate on a scale from 'not at all' to 'very much' how much the mentioned aspects help you to **restore your concentration [relax]**." [lighting, colours, smells, sounds, persons, temperature]."
2. "We would like to ask you to give a global statement about the restorative potential of the environment on a scale from 0 to 100 %."

Fig. 3. Questions to identify outdoor vs. indoor environments with perceived restorative potential (PRP). Separate questions for the investigation of environments after cognitive depletion vs. emotional depletion (in parentheses)

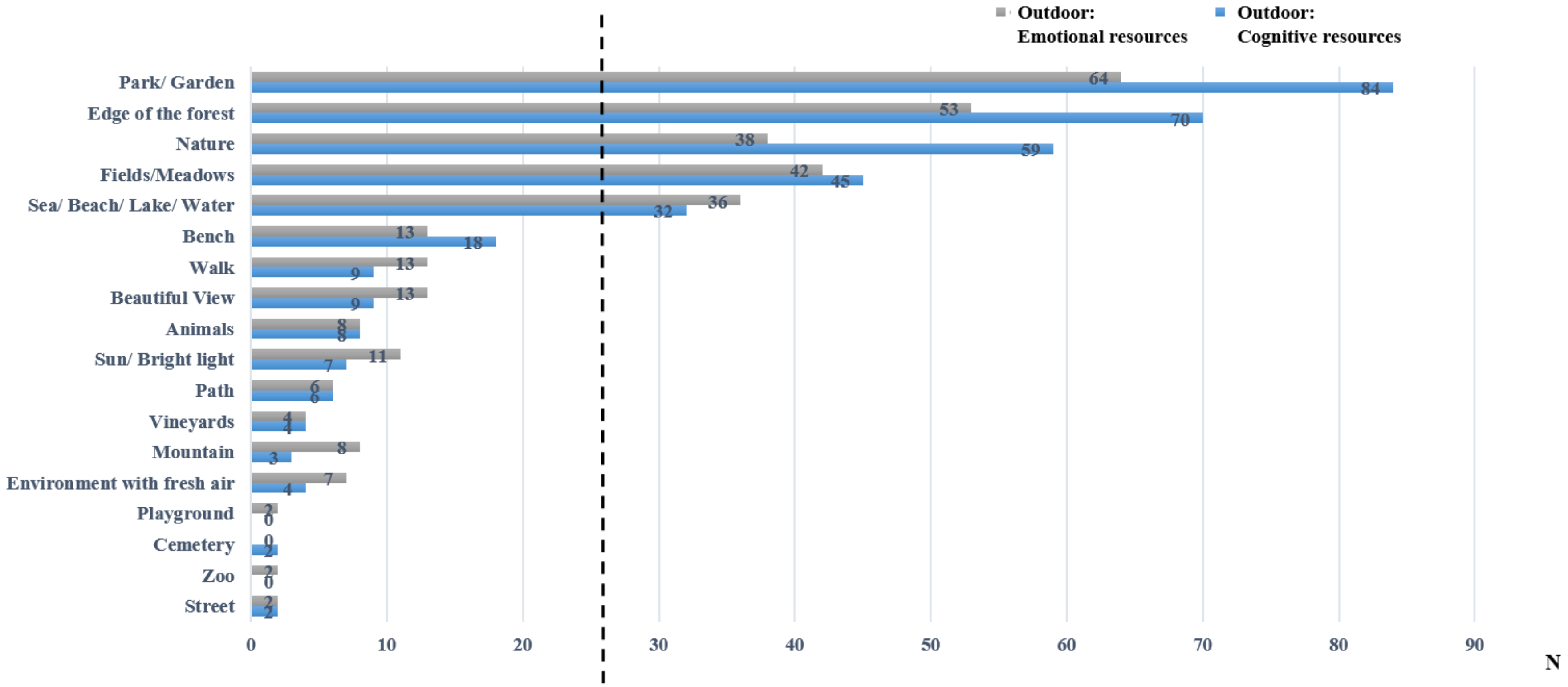


Fig. 4a. Frequency of mentioned outoor environments. *Note.* n = 265. Dotted line indicates 10%. Participants could mention more than one environment, e.g., “I’m going to a park or the sea.”

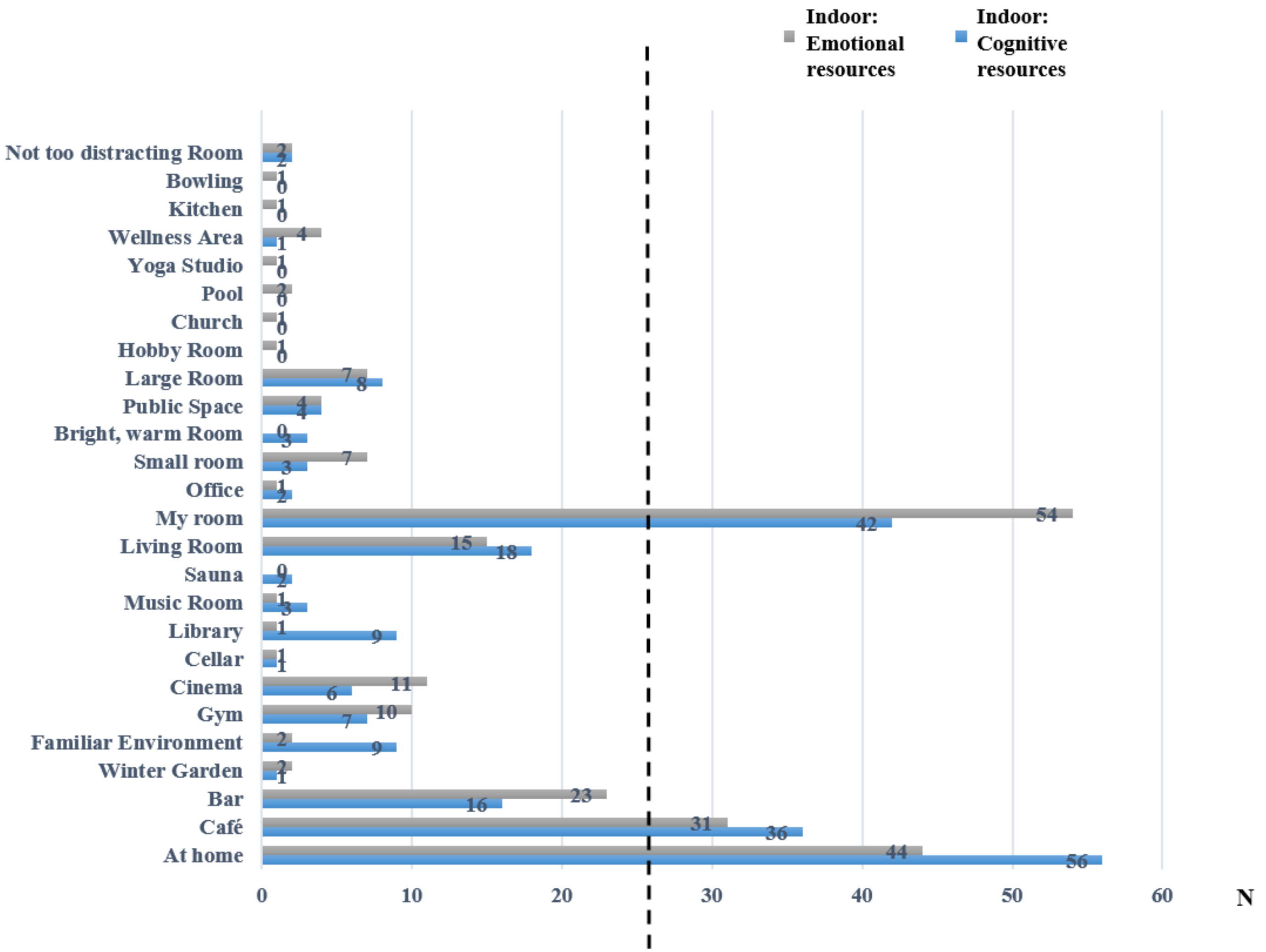


Fig. 4b. Frequency of mentioned indoor environments. *Note.* n = 265. Dotted line indicates 10%.

Participants could mention more than one environment, e.g., "I'm going to my room or the living room."

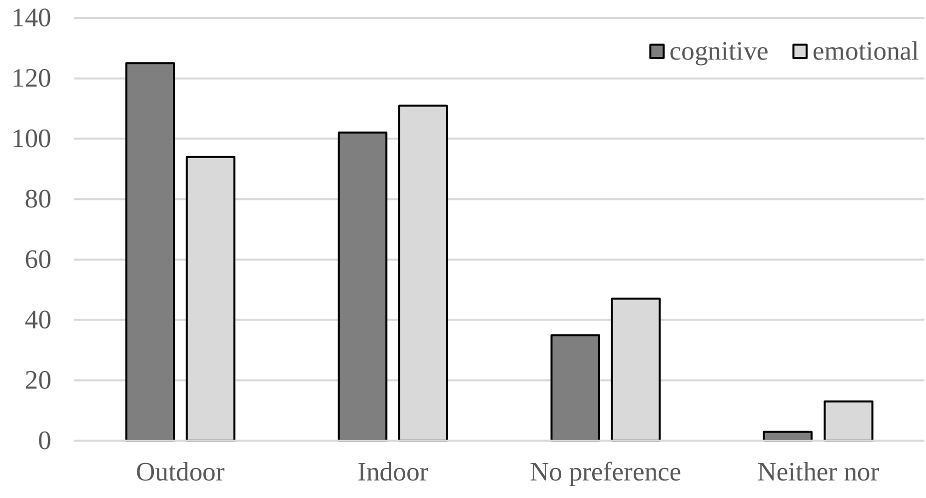


Fig. 5. Frequency analysis of preference for outdoor vs. indoor environments after cognitive vs. emotional depletion. n = 265.

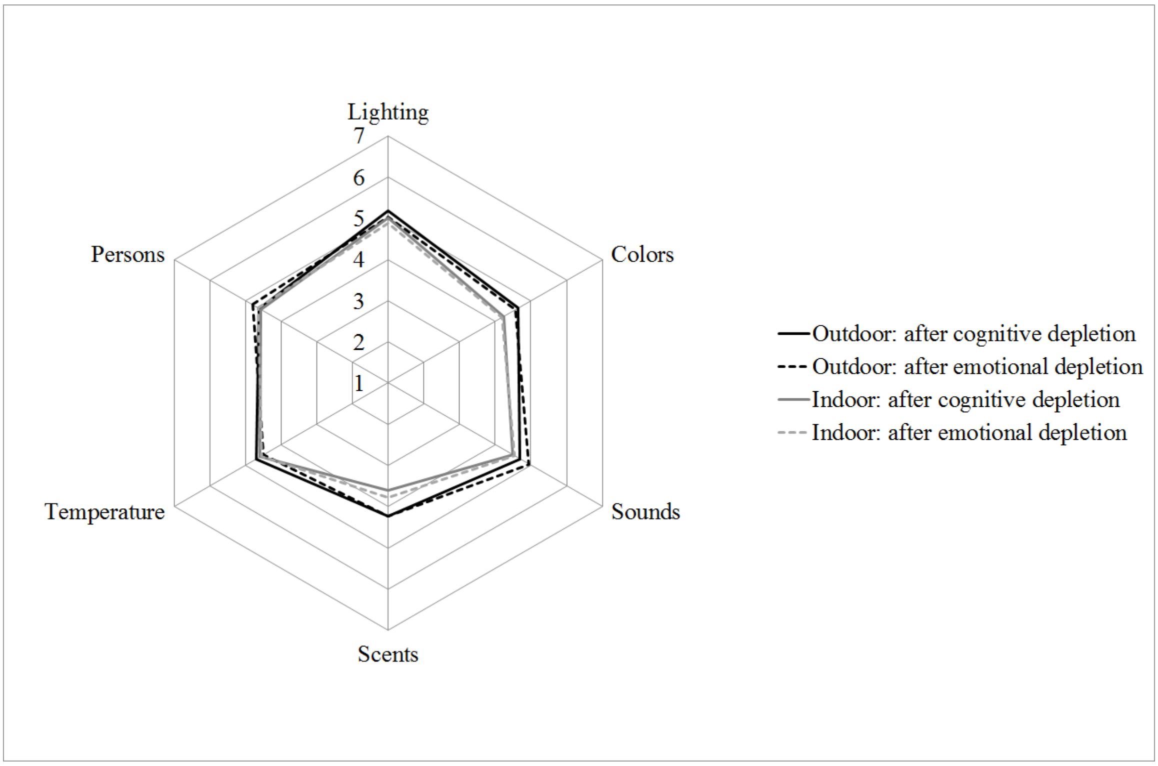


Fig. 6. The restorative potential of specific ambient qualities. *Note.* Higher numbers indicate higher importance for PRP.

Table 1a

Outdoor environments that were evaluated as restorative and their ambient qualities.

Ambient quality	**Codes**	**Outdoor Environments with PRP after Cognitive Depletion**										**Outdoor Environments after Emotional Depletion**									
		Park/ Garden (*n*=84)		Edge of the forest (*n*=70)		Nature (*n*= 59)		Fields/ Meadows (*n*=45)		Sea/ Beach/ Lake/ Water (*n*=32)		Park/ Garden (*n*=64)		Edge of the forest (*n*=53)		Nature (*n*=38)		Fields/ Meadows (*n*=42)		Sea/ Beach/ Lake/ Water (*n*=36)	
		n	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***
Lighting	bright/ light/ sun	68	[81]	44	[63]	51	[86]	33	[73]	27	[84]	51	[80]	28	[53]	27	[71]	34	[81]	29	[81]
	light and shadow	------	------	9	[13]	------	------	------	------	4	[13]	------	------	6	[11]	------	------	------	------	------	------
	dark	------	------	7	[10]	------	------	------	------	------	------	------	------	10	[19]	------	------	------	------	------	------
Colors	green	67	[80]	56	[80]	50	[85]	37	[82]	24	[75]	48	[75]	41	[77]	29	[76]	28	[67]	14	[39]
	red	14	[17]	11	[16]	11	[19]	------	------	------	------	------	------	------	------	4	[11]	------	------	------	------
	yellow	17	[20]	11	[16]	14	[24]	8	[18]	8	[25]	9	[14]	8	[15]	8	[21]	9	[21]	10	[28]
	blue	24	[29]	22	[31]	19	[32]	14	[31]	23	[72]	21	[33]	11	[21]	20	[53]	18	[43]	25	[69]
	brown	20	[24]	39	[56]	23	[39]	24	[53]	7	[22]	16	[25]	22	[42]	17	[45]	12	[29]	5	[14]
	grey	------	------	7	[10]	------	------	7	[16]	------	------	------	------	------	------	------	------	------	------	------	------
	white	------	------	------	------	------	------	5	[11]	5	[16]	8	(13)	------	------	4	[11]	7	[17]	6	[17]
	beige	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	4	[11]
	colorful	23	[27]	7	[10]	12	[20]	------	------	------	------	22	[34]	10	[19]	6	[16]	6	[14]	------	------
Scents	smell of nature	12	[14]	13	[19]	7	[12]	6	[13]	------	------	12	[19]	8	[15]	6	[16]	6	[14]	------	------
	fresh air	16	[19]	12	[17]	9	[15]	8	[18]	5	[16]	9	[14]	6	[11]	4	[11]	9	[21]	------	------
	smells by sea	------	------	------	------	------	------	------	------	12	[38]	------	------	------	------	8	[21]	------	------	17	[47]
	salty air/ sea breeze	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	4	[11]
	wet earth	------	------	------	------	------	------	------	------	------	------	------	------	6	[11]	------	------	------	------	------	------
	leaves	------		7	[10]	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

Note. Results are presented if more than 10% of participants mentioned the ambient quality. Mentions ≥ 25% are marked in grey. Participants could mention more than one feature per ambient quality, e.g., the color ‘green’ and ‘blue’.

Table 1b

Outdoor environments that were evaluated as restorative and their ambient qualities.

Ambient quality	**Codes**	**Outdoor Environments with PRP after Cognitive Depletion**										**Outdoor Environments after Emotional Depletion**									
		Park/ Garden (*n*=84)		Edge of the forest (*n*=70)		Nature (*n*=59)		Fields/ Meadows (*n*=45)		Sea/ Beach/ Lake/ Water (*n*=32)		Park/ Garden (*n*=64)		Edge of the forest (*n*=53)		Nature (*n*=38)		Fields/ Meadows (*n*=42)		Sea/ Beach/ Lake/ Water (*n*=36)	
		n	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***
Sounds	bird sounds	52	[62]	50	[71]	36	[61]	27	[60]	14	[44]	25	[39]	23	[43]	15	[40]	13	[31]	5	[14]
	no sound/ silence	------	------	10	[14]	------	------	------	------	------	------	------	------	------	------	------	------	4	[10]	------	------
	whispering trees	------	------	15	[21]	10	[17]	------	------	------	------	7	[11]	15	[28]	5	[13]	------	------	------	------
	wind	------	------	16	[23]	10	[17]	14	[31]	5	[16]	9	[14]	9	[17]	8	[21]	8	[19]	------	------
	(burbling) water	10	[12]	------	------	------	------	------	------	6	[19]	------	------	6	[11]	5	[13]	------	------	14	[39]
	nature	------	------	------	------	7	[12]	------	------	------	------	7	[11]	------	------	------	------	5	[12]	------	------
	cars/ traffic/ planes	------	------	------	------	------	------	6	[13]	------	------	8	[13]	------	------	4	[11]	7	[17]	------	------
	voices	------	------	------	------	------	------	------	------	5	[16]	13	[20]	------	------	------	------	------	------	------	------
	children/ people	8	[10]	------	------	------	------	------	------	------	------	11	[17]	------	------	------	------	------	------	------	------
	animals	10	[12]	------	------	------	------	5	[11]	------	------	9	[14]	9	[17]	------	------	7	[17]	------	------
Persons	no person	49	[58]	55	[79]	41	[70]	32	[71]	24	[75]	18	[28]	17	[32]	10	[26]	13	[31]	7	[19]
	one person	8	[10]	8	[11]	12	[20]	------	------	------	------	7	[11]	10	[19]	6	[16]	5	[12]	------	------
	two persons	------	------	------	------	------	------	5	[11]	------	------	7	[11]	7	[13]	4	[11]	4	[10]	------	------
	many persons	8	[10]	------	------	------	------	------	------	4	[13]	11	[17]	6	[11]	5	[13]	------	------	8	[22]
	few persons	19	[23]	20	[29]	9	[15]	16	[36]	10	[31]	7	[11]	8	[15]	7	[18]	------	------	4	[11]
	varied number	11	[13]	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
	strangers	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	4	[10]		
Temperature	0-10 °C	------	------	------	------	------	------	------	------	------	------	------	------	8	[15]	------	------	------	------	------	------
	11-15 °C	------	------	------	------	------	------	------	------	------	------	9	[14]	8	[15]	4	[11]	------	------	------	------
	16-20 °C	19	[23]	22	[31]	11	[19]	11	[24]	5	[16]	10	[16]	13	[25]	6	[16]	7	[17]	------	------
	21-25 °C	27	[32]	8	[11]	18	[31]	9	[20]	13	[41]	25	[39]	10	[19]	5	[13]	16	[38]	8	[22]
	26-30 °C	15	[18]	------	------	------	------	------	------	6	[19]	11	[17]	7	[13]	8	[21]	6	[14]	16	[44]
	more than 30 °C	15	[18]	------	------	------	------	------	------	6	[19]	11	[17]	7	[13]	8	[21]	6	[14]	16	[44]
	year-dependent	11	[13]	18	[26]	9	[15]	11	[24]	------	------	7	[11]	------	------	5	[13]	------	------	------	------

Note. Results are presented if more than 10% of participants mentioned the ambient quality. Mentions ≥ 25% are marked in grey.
Participants could mention more than one feature per ambient quality, e.g., the acoustic ‘music’ and ‘voices’.

Table 2a

Indoor environments that were evaluated as restorative and their ambient qualities.

Ambient quality	**Codes**	**Indoor Environments with PRP after Cognitive Depletion**								**Indoor Environments with PRP after Emotional Depletion**							
		Home (*n* =56)		Living room (*n* =18)		My room (*n* =42)		Café (*n* =36)		Home (*n* =44)		Living room (*n* =15)		My room (*n* =54)		Café (*n* =31)	
		N	***[%]***	**N**	***[%]***	**N**	***[%]***	**N**	***[%]***	**N**	***[%]***	**N**	***[%]***	**N**	***[%]***	**N**	***[%]***
Lighting	bright/ light/ sun	42	[75]	11	[61]	28	[67]	25	[69]	33	[75]	10	[67]	34	[63]	14	[45]
	dimmed	------	------	3	[17]	------	------	7	[19]	------	------	2	[13]	------	------	3	[10]
	warm	------	------	------	------	------	------	5	[14]	------	------	------	------	------	------	------	------
	dark	8	[14]	2	[11]	5	[12]	------	------	------	------	------	------	6	[11]	9	[29]
Colors	green	9	[16]	------	------	4	[10]	7	[19]	------	------	4	[27]	7	[13]	5	[16]
	light	------	------	------	------	5	[12]	------	------	5	[11]	------	------	------	------	3	[10]
	dark	------	------	------	------	------	------	------	------	------	------	------	------	------	------	3	[10]
	red	6	[11]	2	[11]	13	[31]	11	[31]	10	[23]	2	[13]	11	[20]	4	[13]
	purple	------	------	------	------	4	[10]	------	------	------	------	------	------	6	[11]	------	------
	blue	12	[21]	4	[22]	------	------	4	[11]	9	[21]	------	------	------	------	------	------
	brown	16	[29]	10	[56]	15	[36]	23	[64]	14	[32]	9	[60]	20	[37]	12	[39]
	orange	7	[13]	3	[17]	6	[14]	------	------	------	------	------	------	------	------	------	------
	grey	------	------	2	[11]	------	------	------	------	------	------	------	------	------	------	------	------
	black	------	------	5	[28]	5	[12]	4	[11]	------	------	------	------	8	[15]	3	[10]
	white	30	[54]	12	[67]	24	[57]	10	[28]	21	[48]	6	[40]	26	[48]	11	[36]
	beige	------	------	------	------	4	[10]	6	[17]	------	------	------	------	------	------	6	[19]
	colorful	11	[20]	3	[17]	4	[10]	------	------	7	[16]	3	[20]	10	[19]	6	[19]
Scents	smell of coffee	------	------	------	------	------	------	25	[69]	------	------	------	------	------	------	18	[58]
	freshly-baked bread/ cake	------	------	------	------	------	------	10	[28]	------	------	------	------	------	------	6	[19]
	neutral smell	7	[13]	3	[17]	5	[12]	------	------	------	------	------	------	6	[11]	------	------
	smell of home	------	------	2	[11]	------	------	------	------	------	------	------	------	------	------	------	------
	food	------	------	3	[17]	------	------	4	[11]	------	------	------	------	------	------	3	[10]

Note. Results are presented if more than 10% of participants mentioned the ambient quality. Mentions $\geq$ 25% are marked in grey. Participants could mention more than one feature per ambient quality, e.g., the color 'green' and 'blue'.

Table 2b

Indoor environments that were evaluated as restorative and their ambient qualities.

Ambient quality	Codes	Indoor Environments with PRP after Cognitive Depletion								Indoor Environments with PRP after Emotional Depletion							
		Home (n=56)		Living room (n=18)		My room (n=42)		Café (n=36)		Home (n=44)		Living room (n=15)		My room (n=54)		Café (n=31)	
		n	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***	***n***	***[%]***
Sounds	music/ singing	17	[30]	3	[17]	6	[14]	12	[33]	17	[39]	------	------	12	[22]	9	[29]
	no sound/ silence	21	[38]	9	[50]	20	[48]	------	------	15	[34]	4	[27]	29	[54]	------	------
	TV/ radio/ cinema	9	[16]	3	[17]	6	[14]	------	------	------	------	2	[13]	------	------	------	------
	voices	8	[14]	2	[11]	------	------	27	[75]	------	------	4	[27]	------	------	23	[74]
	laughing	------	------	------	------	------	------	------	------	------	------	------	------	------	------	3	[10]
	dishes	------	------	------	------	------	------	6	[17]	------	------	------	------	------	------	5	[16]
	coffee machine	------	------	------	------	------	------	4	[11]	------	------	------	------	------	------	5	[16]
	background noise	------	------	2	[11]	------	------	------	------	------	------	------	------	------	------	------	------
Persons	no person	19	[34]	7	[38]	15	[36]	13	[36]	12	[27]	4	[27]	24	[44]	------	------
	one person	17	[30]	3	[17]	25	[60]	------	------	17	[39]	2	[13]	19	[35]	------	------
	two persons	9	[16]	4	[22]	------	------	------	------	6	[14]	2	[13]	------	------	------	------
	three persons	------	------	3	[17]	------	------	------	------	------	------	2	[13]	------	------	------	------
	four persona	------	------	------	------	------	------	------	------	------	------	3	[20]	------	------	------	------
	many persons	------	------	------	------	------	------	7	[19]	------	------			------	------	9	[29]
Temperature	16-20 °C	12	[21]	7	[39]	14	[33]	7	[19]	11	[25]	3	[20]	20	[37]	6	[19]
	21-25 °C	37	[66]	10	[56]	25	[60]	27	[75]	26	[59]	12	[80]	34	[63]	24	[77]
	26-30 °C	6	[11]	2	[11]	------	------	------	------	------	------	------	------	------	------	------	------
	more than 30 °C	6	[11]	2	[11]	------	------	------	------	------	------	------	------	------	------	------	------
	year-dependent	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

Note. Results are presented if more than 10% of participants mentioned the ambient quality. Mentions ≥ 25% are marked in grey. Participants could mention more than one feature per ambient quality, e.g,. the acoustic ‘music’ and ‘voices’.

Supplemental Materials: Additional Details of Procedures and Analyses

Table S1a. Cohen's Kappa. Question 1.

	Dummy Coding	Naming
Question 1	Outdoor	.73
	Indoor	.78

Note. The following results comprise analyses with Cohen's Kappa ≥ .60.

Table S1b. Cohen's Kappa. ART outdoor. Question 3.

Dummy Coding	Naming 1	Naming 2	Naming 3	Naming 4	Naming 5	Naming 6
Scents	.87	.84	.72	.91	------	------
Lighting	.69	.82	.38	------	------	------
Colors	.98	.95	.96	1.00	1.00	1.00
Sounds	.99	.99	.96	1.00	------	------
Persons	.92	.76	------	------	------	------
Temperature	.90	.57	------	------	------	------

Note. The following results comprise analyses with Cohen's Kappa ≥ .60. Missing values: E.g., participants mentioned three different lightings. Hence, naming 4, 5 and 6 are missing.

Table S1c. Cohen's Kappa. SRT outdoor. Question 3.

Dummy Coding	Naming 1	Naming 2	Naming 3	Naming 4	Naming 5	Naming 6
Scents	.89	.82	.60	.91	------	------
Lighting	.90	.81	------	------	------	------
Colors	.93	.97	.95	.97	.91	.69
Sounds	.99	.97	.96	.91	------	------
Persons	.98	1.00	1.00	------	------	------
Temperature	.99	.83	------	------	------	------

Note. The following results comprise analyses with Cohen's Kappa ≥ .60. Missing values: E.g., participants mentioned three different lightings. Hence, naming 4, 5 and 6 are missing.

Table S1d. Cohen's Kappa. ART indoor. Question 3.

Dummy Coding	Naming 1	Naming 2	Naming 3	Naming 4	Naming 5	Naming 6
Scents	.91	.85	.88	1.00	------	------
Lighting	.99	.82	------	------	------	------
Colors	.98	.97	.93	.83	.65	------
Sounds	.97	.93	.87	.85	------	------
Persons	.94	.96	1.00	------	------	------
Temperature	.99	.60	------	------	------	------

Note. The following results comprise analyses with Cohen's Kappa ≥ .60. Missing values: E.g., participants mentioned three different lightings. Hence, naming 4, 5 and 6 are missing.

Table S1e. Cohen's Kappa. SRT indoor. Question 3.

Dummy Coding	Naming 1	Naming 2	Naming 3	Naming 4	Naming 5	Naming 6
Scents	.89	.84	.90	1.00	------	------
Lighting	.98	.70	------	------	------	------
Colors	.99	1.00	.99	1.00	1.00	1.00
Sounds	.99	.94	.94	1.00	------	------
Persons	.94	1.00	1.00	------	------	------
Temperature	.96	1.00	------	------	------	------

Note. The following results comprise analyses with Cohen's Kappa ≥ .60. Missing values: E.g., participants mentioned three different lightings. Hence, naming 4, 5 and 6 are missing.

Table S2. Means and standard deviations. Restorative potential of ambient qualities. n = 262.

		After cognitive depletion		**After emotional depletion**	
Ambient quality	**Overall**	**Outdoor Environments**	**Indoor Environments**	**Outdoor Environments**	**Indoor Environments**
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Lighting	5.02 (.07)	5.17 (1.36)	5.00 (1.47)	5.03 (1.44)	4.87 (1.49)
Colors	4.40 (.07)	4.64 (1.49)	4.23 (1.54)	4.55 (1.49)	4.18 (1.52)
Scents	3.96 (.08)	4.24 (1.53)	3.60 (1.72)	4.24 (1.70)	3.77 (1.60)
Sounds	4.66 (.07)	4.68 (1.65)	4.48 (1.81)	4.94 (1.51)	4.54 (1.64)
Persons	4.66 (.07)	4.61 (1.90)	4.57 (1.93)	4.80 (1.53)	4.65 (1.82)
Temperature	4.58 (.06)	4.69 (1.45)	4.58 (1.41)	4.50 (1.78)	4.55 (1.37)

Table S3a. Means and standard deviations.

Interaction ambient quality x environment. *n* = 262.

	Ambient quality	***M***	***(SD)***
Outdoor	Lightings	5.10	.07
	Colors	4.60	.08
	Sounds	4.81	.08
	Scents	4.24	.08
	Temperatures	4.60	.08
	Persons	4.71	.08
Indoor	Lightings	4.94	.08
	Colors	4.20	.08
	Sounds	4.51	.09
	Scents	3.69	.09
	Temperatures	4.57	.07
	Persons	4.61	.09

Table S3b. Means and standard deviations.

Interaction ambient quality x type of depletion. *n* = 262.

	Ambient quality	***M***	***(SD)***
After cognitive depletion	Lightings	5.08	.07
	Colors	4.43	.08
	Sounds	4.58	.09
	Scents	3.92	.08
	Temperatures	4.64	.08
	Persons	4.59	.10
After emotional depletion	Lightings	4.95	.08
	Colors	4.37	.08
	Sounds	4.74	.08
	Scents	4.01	.09
	Temperatures	4.53	.08
	Persons	4.73	.08

Table S4a. Correlations between the mentioned ambient qualities and the global indicator of PRP. Outdoor.

		Global indicator of PRP: PRP after Cognitive Depletion						**Global indicator of PRP: PRP after Emotional Depletion**					
		Five most Restorative environ-ments (*n*=205)	**Park/ Garden (*n*=77)**	**Edge of the forest (*n*=64)**	**Nature (n=56)**	**Fields/ Meadows (*n*=43)**	**Sea/ Beach/ Lake/ Water (*n*=32)**	**Five most Restorative environ-ments (*n*=168)**	**Park/ Garden (*n*=61)**	**Edge of the forest (*n*=52)**	**Nature (*n*=36)**	**Fields/ Meadows (*n*=40)**	**Sea/ Beach/ Lake/ Water (*n*=32)**
	M (SD)	78.99 (20.54)	75.42 (19.44)	85.31 (13.65)	80.59 (21.12)	83.21 (16.59)	75.97 (26.05)	78.95 (14.59)	77.05 (11.96)	78.67 (16.68)	78.72 (13.76)	76.25 (18.39)	85.28 (11.76)
Restorative potential													
…Lighting	…light/ sun	-.06	-.07	**.29***	.00	.07	**-.30**$^{+}$	.04	.00	.21	-.13	.04	.04
…Colors	…green	.10	.07	-.15	-.00	-.00	**.47****	-.02	.05	.17	-.37	.23	-.16
	…yellow	----	----	----	----	----	-.03	----	----	----	----	----	-.21
	…blue	.01	.16	**.26***	-.00	-.17	-.05	----	.01	----	-.19	.18	-.07
	…brown	----	----	**-.21**$^{+}$	.05	.14	----	----	**-.27***	.14	.09	.16	----
	…colorful	----	----	----	-----	----	----	----	.12	-.09	----	----	----
…Odour	…smells by sea	----	----	----	-----	----	-.21	----	----	----	----	----	
…Sounds	…bird sounds	.05	.08	.02	-.00	.12	.09	----	.16	-.03	.03	-.11	----
	…whispering trees	----	----	----	----	----	----	----	----	.14	-.06	-.02	----
	…wind	----	----	----	----	.07	----	----	----	----	----	----	----
	…burbling water	----	----	----	----	----	----	----	----	----	----	----	**.33**$^{+}$
…Persons	…no person	-.07	-.18	.01	-.03	-.00	-.11	----	.03	-.10	-.24	-.16	-.22
	…few persons	----	----	-.14	----	.21	-.06	----	----	----	----	----	----
…Tempera-ture	…16-20 *°C*	----	----	**-.28***	----	----	----	----	----	-.07	----	----	----
	…21-25 *°C*	----	.00	----	-.06	----	**.33**$^{+}$	----	.07	----	----	.08	----
	…26-30 *°C*	----	----	----	----	----	----	----	----	----	----	----	-.29
	…more than 30 *°C*	----	----	-----	----	----	----	----	----	------	----	----	-.29
	…year-dependent	----	----	-.06	----	----	----	----	----	----	----	----	----

Note. $^{+}p < .10$ (one-sided), $*p < .05$ (two-sided), $**p < .01$ (two-sided). Correlations were tested if ≥ 25 % of participants mentioned the specific environmental feature.

Table S4b. Correlations between the mentioned ambient qualities and the global indicator of PRP. Indoor.

		Global indicator of PRP: PRP after Cognitive Depletion					**Global indicator of PRP: PRP after Emotional Depletion**				
		Four most Restorative environments (*n*=140)	**Home (*n*=55)**	**Living room (*n*=15)**	**My room (*n*=38)**	**Café (*n*=36)**	**Four most Restorative environment (*n*=131)**	**Home (*n*=42)**	**Living room (*n*=13)**	**My room (*n*=49)**	**Café (*n*=30)**
	M (SD)	76.68 (21.27)	80.07 (18.52)	73.07 (23.98)	71.74 (29.67)	77.19 (15.65)	70.00 (21.56)	75.10 (23.24)	74.08 (12.69)	69.33 (17.69)	63.53 (25.82)
Restorative potential											
…Lighting	…light/ sun	-.04	-.15	-.27	-.12	.24	-.02	-.09	.47	.19	**-.40***
	…dark	----	----	----	----	----	----	----	----	----	
…Colors	…white	-.02	.09	.18	-.03	-.17	-.01	.08	-12	-.02	-.23
	…brown	.05	.09	.33	.23	**-.35***	.06	**.27**$^{+}$	-.05	-.08	.12
	…red	----	----	----	-.25	.04	----	----	----	----	----
	…black	----	----	.09	----	-.14	----	----	----	----	----
	…green	----	----	----	----	----	----	----	-.17	----	----
…Odour	…smell of coffee	----	----	----	----	-.05	----	----	----	----	-.01
	…freshly-baked bread/ cake	----	----	----	----	.21	----	----	----	----	----
…Sounds	…music/ singing	----	.05	----	----	.07	----	.10	----	----	**.32**$^{+}$
	…no sound	----	**-.23**$^{+}$	-.24	-.03	----	----	-.13	.15	.07	----
	...voices	----	----	----	----	**-.29**$^{+}$	----	----	-.06	----	**.52****
…Persons	…no person	.11	.12	.41	.15	----	----	.22	-.18	-.04	----
	…one person	----	**-.33***	----	-.16	----	----	-.13	----	----	----
	…two person	----	----	----	----	----	----	**-.38***	----	----	----
	…many person	----	----	----	----	----	----	----	----	----	**-.36***
…Temperature	…16-20 *°C*	----	----	.32	-.05	----	----	.11	----	.03	----
	…21-25 *°C*	-.01	**-.22**$^{+}$	-.32	.12	.12	-.03	-.03	.32	.00	-.05

Note. $^{+}p < .10$ (one-sided), $*p < .05$ (two-sided), $**p<.01$ (two-sided).

Chapter 3: A contribution to theory testing: Confirming restorative environments in the lab

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

Brid Sona, Anna Steidle, and Erik Dietl

Abstract

To deal with stress and exhaustion at work, personal resources need to be replenished during breaks. The aim of the present study was to test the restorative potential of *sensory-enriched break environments (SEBEs)*, particularly focusing on the type of the simulated 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 more restorative than a standard break room, which in turn facilitated the recovery of personal resources (mood, self-control, feelings of restoration, fatigue, arousal). Moreover, adding a congruent scent to an audiovisual simulation indirectly facilitated the recovery of personal resources via greater scent pleasantness and higher perceived restorativeness. The current study shows various opportunities for sensory enrichment to foster restoration in break environments.

Keywords: ambient scent, restorative environments, simulation, perceived restorativeness, personal resources

Introduction

In the face of increasing demands and stress levels at work (Hipp, Gulwadi, Alves, & Sequeira, 2016; Sonnentag, Binnewies, & Mojza, 2011), humans are increasingly interested in creating restorative environments. Numerous studies have shown that natural environments are particularly effective in helping to replenish personal resources (Beute & de Kort, 2014a, 2014b; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Ulrich et al., 1991). However, work breaks in natural environments are not always available or accessible. Since most people in the Western world spend 80% to 90% of their time in buildings (Urlaub, Hellwig, van Treeck, & Sedlbauer, 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).

It is known that dedicated break environments can help to perceive a mental and spatial distance from work-related demands (Hartig, Korpela, Evans, & Gärling, 1997; Felsten, 2009), and thereby foster recovery during work breaks. Even environments that mimic nature affect positive moods and better cognitive function. For instance, mimicking nature-like environments leads to increased mood and better cognitive functioning (see also Hartig, Böök, Garvill, Olsson, & Gärling, 1996). 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, & Pratt, 2008, p. 203).

For both real and artificial environments, the *Attention Restoration Theory (ART*, Kaplan, 1995) describes four dimensions that are typical of restorative environments: a) a certain soft fascination of the environment, which emphasizes effortless attention (e.g., the observation of clouds vs. hard fascination, e.g., watching a thriller); b) mental or spatial detachment from one's usual environment; c) coherence between all sensory impressions to generate a sense of extent; and d) compatibility between personal requirements and environmental conditions. Environments which are high in these qualities support recovery (Berto, 2005; Felsten, 2009; White et al., 2010). Hence, to improve recovery in indoor break environments, we aim at contributing to the knowledge of how the simulation of restorative environments can contribute to the creation of 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 perceptions of restorativeness 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 unrestorative built environments (urban settings) with natural environments (Hartig et al., 2003; Berto, Baroni, Zainaghi, & Bettella, 2010). In contrast, we compared indoor and outdoor *sensory-enriched break environments (SEBEs)* that both might be restorative to some degree.

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, Hygge, Green, & Dimberg, 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, Walker, Song, Kobayashi, & Hodges, 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 perceived restorativeness or on resource recovery as dependent variables. The idea of the ART that environments promote resources because they are perceived as restorative 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, Rouby, Farget, Vigouroux, & Holley, 2002). Hence, we wanted to understand how the simulation of an environment through visual, auditory, and olfactory stimuli affects perceived restorativeness and, in turn, resource recovery among depleted persons. Doing so, we will outline the psychological pathway from specific environmental stimuli through perception to recovery.

Simulating restorative outdoor environments

Recovery effects are more pronounced for real than for simulated nature (Kjellgren & Buhrkall, 2010). 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, & Sowden, 2013). Similarly, merely viewing nature supports recovery (Felsten, 2009; Friedman et al., 2008; Kjellgren & Buhrkall, 2010). However, the study by Kjellgren & 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 & IJsselsteijn 2006; Depledge, Stone, & Bird, 2011). 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 promote recovery more strongly than visual or auditory simulations separately.

Moreover, the idea that an impression of restorativeness mediates the effect of nature on resource recovery has been supported for the actual experience of nature on emotions or affective well-being. Perceived restorativeness has been shown to mediate the impact of environmental features (e.g., presence of nature, greenness) on happiness, positive/negative affect (Marselle, Irvine, Lorenzo-Arribas, & Warber, 2016) and on quality of life (Hipp, Gulwadi, Alves & Sequeira, 2016).

However, so far, no study has tested whether perceived restorativeness also mediates the effects of simulated nature on affective resources and whether these indirect effects also refill other personal resources like cognitive or energy resources. Resource theories differentiate between three related but distinct resources: *(1) energy resources*, which can be defined as reduced fatigue and increased feelings of restoration and vitality; *(2) affective resources*, which can be described as positive, negative mood, and arousal; and *(3) cognitive resources*, in form of attentional control and willpower (Beute & de Kort, 2014a, 2014b; Berman et al., 2008; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Ulrich et al., 1991).

Consequently, we expect that:

H1a: Break rooms simulating nature 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 energy and affective and cognitive resources. These effects are mediated by perceived restorativeness.

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 & 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 that:

H2a: Break rooms simulating an indoor environment 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 energy and affective and cognitive resources. These effects are mediated by perceived restorativeness.

However, since a large part of recovery research suggests the enhanced benefits of nature (Kaplan & 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.

H3a: SEBEs simulating a natural environment are perceived as more restorative than SEBEs simulating an indoor environment.

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

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, & 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, & Henderson, 1996). Second, congruent scents enhance the perceived realism of an environment. In support, Ramic-Brkic, Chalmers, Boulanger, Pattanaik, and Covington (2009) found the effects of adding congruent scents compensated for quality differences of visual inputs (high vs. low quality renderings of blades of grass). Adding the 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, Janssens, Swinnen, & van Cleempoel (2014) and Herrmann, Zidansek, Sprott, and Spangenberg (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 perception of restorativeness of a simulated environment and, consequently, recovery. More pleasant, congruent scents should foster perceived restorativeness due to deeper immersion in the scene. Thus, we expected that:

H4a: in SEBEs, congruent scents are perceived as more pleasant than neutral scents, which indirectly increases the perceived restorativeness.

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 restorativeness.

Method

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.

Subjects

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.

Setting and conditions

The study was conducted in two real offices, which we used for the study, labeled ‘work room’ and ‘break room.’ This arrangement of settings 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. 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 (see also de Dear & 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. 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; see Table 1). The orders of assigning participants to conditions was randomized.

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.

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. S1 in supplemental material).

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 (see Fig. S1 in supplemental material). 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, Bella, Roy, Peretz, & Lupien, 2003; see also in supplemental material: “Auditory Material”).

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 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. In a pre-test (n = 12), the intensity of the respective ambient scents was tested 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.

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 to ensure that the air quality was neutral in all conditions (e.g., to neutralize unpleasant vapors seeping out from building materials). See Figure 1 for a graphic of the break room.

Physical Conditions in the Rooms. For further information, see in supplemental materials: “Physical Conditions in the Rooms”.

Measures

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). The perception of the restorative quality of the break rooms was assessed using the *Perceived Restorativeness Scale (PRS;* Hartig et al., 1997), a standard measure of restorative environments which consists of the four dimensions of the *Attention Restoration Theory* (ART; Kaplan, 1995) and is frequently used in the literature (e.g., Berto, 2005; Felsten, 2009; White et al., 2010). Items were answered on a six-point Likert scale (1 = little – 6 = extremely; e.g., ‘This place fascinates me’; ‘This is a place where I can do what I enjoy’). The internal consistency of the PRS was $\alpha = .94$.

Measures of personal resources. To assess restoration effects, three types of personal resources were assessed: energy resources, affective resources, and cognitive resources. Participants responded three times to the resource measures: before and after the depletion phase, and during the post-restoration phase.

Energy resources. We used two subscales of *Nitsch's Personal State Scale* (1976; adapted from Apenburg, 1986) to investigate participants' *recovery* (five items, e.g., 'relaxed') and *fatigue* (three items, e.g., 'tired') using a six-point Likert scale (1 = little – 6 = extremely). The scales showed good reliability at all three measuring points (alphas between .75 and .86). *Affective resources.* We used two subscales of *Nitsch's Personal State Scale* (1976; adapted from Apenburg, 1986) to investigate subjects' *mood* (six items, e.g,. 'happy') and *arousal* (six items, e.g., 'calm'). The scales showed good reliability at all three measuring points (.79 and .92). *Cognitive resources.* Participants assessed their *self-regulatory resources* with the 10-item short form of the *State Self-Control Capacity Scale* (Ciarocco, Twenge, Muraven, & Tice, 2004; e.g., 'I feel exhausted') using a six-point Likert scale (1: not at all – 6: extremely). The scale showed good reliability at all three measuring points (alphas between .84 and .90). High levels of personal resources are indicated by a high amount of self-control capacity.

Procedure

The lab study comprised three phases adapted from Berto's (2005) paradigm: a depletion phase, a restoration phase, and a post-restoration phase (see Fig. 2).

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. These measures served as baseline measures of participants' personal resources. During the subsequent depletion phase, participants worked on three cognitively demanding (ego-depleting) 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 & 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.

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.

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.

Analytic Strategy

Manipulation checks for resource depletion were conducted with repeated measurement ANOVAs. For a better comparison between different analyses, all hypotheses were tested with measures of association. First, restoration effects were examined with correlation analyses for variables of room perception and recovery of personal resources (using indicator coding for conditions). Subsequently, to demonstrate the proposed psychological chain of effects, 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 & 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. 3). 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 & 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, feelings of restoration, mood, arousal, and state of self-control capacity.

Results

Manipulation checks

Resource depletion. Table 2 provides means and standard deviations for personal resources and perception of the break room as well as results of the manipulation check for personal resources. A 2(time: t1 vs. t2) x 5(condition) ANOVA on the subjective measures of the resources was conducted. As expected, participants' feelings of restoration, mood, and self-control capacities decreased from t1 to t2, indicating depletion. Arousal and fatigue decreased from t1 to t2. Together with the decrease in mood, the drop in arousal is also interpreted as an exhaustion response. Moreover, unexpectedly, the interaction between time and condition yielded a significant effect on self-control capacity and mood. 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 & de Kort, 2014).

Ambient scents. The ambient scents should be induced above odour detection threshold, but below odour identification. A question with open-response format indicated that in the control group (group without induced scents), no participant smelled any scent, except one participant (smelling ‘freshness’). In the two scented conditions, 36.7% mentioned that they could smell a scent (63.3% did not). In the scented nature condition, participants mentioned the smell of ‘freshness’, ‘flowery’, ‘sweet’, ‘lemon’, ‘lavender’ and ‘not known’. In the scented lounge condition, participants mentioned the smell of ‘sweet’, ‘sandalwood’, ‘peach’ and ‘not known’. Overall, the mentioned scents fit to the presented visual stimuli. Thus, the posited congruency between visual and olfactory input can be assumed. As expected, a precise odour identification was not possible.

Effects on comfort of the break room and perceived restorativeness

Table 3 provides an overview of correlations between environment, perception of the break room conditions, and recovery of personal resources (see also Table S1 in supplemental materials for means and standard deviations for the perception of the break room). SEBEs simulating nature were perceived as more pleasant in view and more restorative 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 marginally more restorative ($r = .18$, $p < .10$) in the nature simulations than in the lounge simulations. These results suggest support of 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.

Indirect effects on recovery

Table 4 depicts the results of mediation analyses. The first mediation model (SMM1) tested whether SEBEs promoted personal resources through perceived restorativeness (H1b and H2b). Results of SMM1 yielded a significant indirect effect on all five personal resources. This indicates that SEBEs improve perceived restorativeness, which in turn decreases arousal and fatigue, and increases feelings of restoration, mood, and self-control capacity (see Table 4, SMM1). Overall, this supports H1b and H2b.

The second serial mediation model (SMM2) tested whether the simulated nature environment promoted personal resources through perceived restorativeness (H3b) compared to an indoor break environment. Results of SMM2 yielded marginal significant effects of the simulated environment on perceived restorativeness, and significant indirect effects on four personal resources, except arousal. 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 and increasing feelings of restoration, mood, and self-control capacity (see Table 4, SMM2). Overall, this supports H3b.

The third sequential mediation model (SMM3) tested whether SEBEs with congruent scents were linked to personal resources through the sequential mediation of perceived scent pleasantness and perceived restorativeness (H4b). Results of SMM3 yielded significant indirect effects through pleasantness of scent on perceived restorativeness and, in turn, on all five personal resources. This indicates that the greater pleasantness of scented environments fosters perceived restorativeness, which in turn increases mood, feelings of restoration and self-control capacity, and decreases arousal and fatigue (see Table 4, SMM3 and Fig. 4 for a graphical depiction). Overall, the results support H4b.

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 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 could not be shown with correlation analyses. Thus, the psychological process for indicating beneficial effects of indoor environments may be more complex, calling for sophisticated analyses. 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 restorativeness. Overall, our proposed conceptual model (see Fig. 3) 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.

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 perceived restorativeness or on resource recovery as dependent variables. In contrast, we outlined the psychological pathway from specific environmental stimuli through perceived restorativeness to recovery. In line with past research (Marselle et al., 2016), we found that perceived restorativeness represents an important mediator in the relationship between the environment and the recovery of personal resources. Thus, PRS facilitates concrete recovery effects as described by Attention Restoration Theory.

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 & IJsselsteijn, 2006). Our study was able to show that using an additional congruent scent indirectly intensified the room pleasantness of the simulated audiovisual environment and the recovery effects on mood, feelings of restoration, arousal, and self-control capacity. Due to the direct connection between the olfactory bulb and the limbic system

(Bosmans, 2006; Krishna, 2012), the influence of scent on mood seems obvious and is in line with previous research showing that ambient scents foster positive mood (Baron, 1983, 1986, 1990; Herz, 2004; Michon, Chebat, & 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.

Limitations and future research questions

Despite the insights presented, at least five questions regarding the restorative potential of simulated break environments remain to be answered by future research. 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). According to Gulwadi (2006), natural environments are 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 should 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 & Berman, 2010). Contrary to this expectation, a recent study (Yoye & 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.

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.

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, Tanzer, Darvin, & Borer, 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.

Conclusion

In all the situations described, the use of scents should be considered carefully because it is far more difficult to direct precisely a scent at a single individual than it is with an audiovisual presentation. Nevertheless, it could be concluded that recovery may begin with the vision of an environment, but flourishes from sensory-enriched impressions.

References

Alvarsson, J. J., Wiens, S., & Nilsson, M. E. (2010). Stress recovery during exposure to nature sound and environmental noise. *International Journal of Environmental Research and Public Health, 7*(3), 1036–1046. doi:10.3390/ijerph7031036

Annerstedt, M., Jönsson, P., Wallergård, M., Johansson, G., Karlson, B., Grahn, P., Hansen, A. M., & Währborg, P. (2013). Inducing physiological stress recovery with sounds of nature in a virtual reality forest-results from a pilot study. *Physiology & Behavior, 118,* 240–250. doi:10.1016/j.physbeh.2013.05.023

Apenburg, E. (1986). Befindlichkeitsbeschreibung als Methode der Beanspruchungsmessung [State description as a method for measuring stress]. *Psychologie und Praxis, 30,* 3–14.

ASHRAE Standard 55—thermal environmental conditions for human occupancy, *ASHRAE Inc.*, 1992, Atlanta.

Baron, R.A. (1983). The "sweet smell of success"? The impact of pleasant artificial scents on evaluation of job applicants. *Journal of Applied Psychology, 68,*709-713.

Baron, R.A. (1986). Self-presentation in job interviews: When there can be "too much of a good thing." *Journal of Applied Social Psychology*, *16*, 16-28.

Baron, R. A. (1990). Environmentally induced positive affect: Its impact on self-efficacy, task performance, negotiation, and conflict. *Journal of Applied Social Psychology*, *20*(5), 368-384.

Beil, K., & Hanes, D. (2013). The influence of urban natural and built environments on physiological and psychological measures of stress - a pilot study. *International Journal of Environmental Research and Public Health, 10,* 1250-1267. doi:10.3390/ijerph10041250

Bensafi, M., Rouby, C., Farget, V., Vigouroux, M., & Holley, A. (2002). Asymmetry of pleasant vs. unpleasant odor processing during affective judgment in humans. *Neuroscience Letters, 328*(3), 309–313. doi:10.1016/S0304-3940(02)00548-7

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science, 19*(12), 1207–1212. doi:10.1111/j.1467-9280.2008.02225.x

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology*, *25*(3), 249–259. doi:10.1016/j.jenvp.2005.07.001

Berto, R., Baroni, M. R., Zainaghi, A., & Bettella, S. (2010). An exploratory study of the effect of high and low fascination environments on attentional fatigue. *Journal of Environmental Psychology*, *30*, 494–500. doi:10.1016/j.jenvp.2009.12.002

Beute, F., & de Kort, Y. A. W. (2014a). Natural resistance: Exposure to nature and self-regulation, mood, and physiology after ego-depletion. *Journal of Environmental Psychology, 40*, 167–178. doi:10.1016/j.jenvp.2014.06.004

Beute, F., & de Kort, Y. A. W. (2014b). Salutogenic effects of the environment: Review of health protective effects of nature and daylight. *Applied Psychology: Health and Well-Being*, *6*(1), 67–95. doi:10.1111/aphw.12019

Bosmans, A. (2006). Scents and sensibility: When do (in)congruent ambient scents influence product evaluations? *Journal of Marketing*, *70*(3), 32–43. doi:10.1509/jmkg.70.3.32

Ciarocco, N. J., Twenge, J. M., Muraven, M., & Tice, D. M. *The state self-control capacity scale: Reliability, validity, and correlations with physical and psychological stress*. Unpublished manuscript, San Diego State University.

Cooper, C. L. (Ed.). (1983). *Stress research: Issues for the eighties*. Chichester, New York: Wiley.

de Dear, R. J., & Brager, G. S. (2002). Thermal comfort in naturally ventilated buildings: revisions to ASHRAE Standard 55, *Energy & Building*, *34*, 549-561.

De Kort, Y. A. W., & IJsselsteijn, W. A. (2006). Reality check: The role of realism in stress reduction using media technology. *Cyberpsychology & Behavior*, *9*(2), 230–233.

doi:10.1089/cpb.2006.9.230

Dinh, H. Q., Walker, N., Hodges, L. F., Song, C., Kobayashi, A., & Hodges, L. F. (1999). Evaluating the importance of multi-sensory input on memory and the sense of presence in virtual environments. In IEEE (Ed.), *Virtual Reality* (pp. 222–228).

Dormann, C., & De Jonge, J. (2006). Stressors, resources, and strain at work: A longitudinal test of the triple-match principle. *Journal of Applied Psychology, 91*(6), 1359–1374. doi:10.1037/0021-9010.91.5.1359

Doucé, L., Janssens, W., Swinnen, G., & van Cleempoel, K. (2014). Influencing consumer reactions towards a tidy versus a messy store using pleasant ambient scents. *Journal of Environmental Psychology, 40,* 351–358. doi:10.1016/j.jenvp.2014.09.002

Emfield, A. G., & Neider, M. B. (2014). Evaluating visual and auditory contributions to the cognitive restoration effect, *Frontiers in Psychology, 5*, 1-11. doi: 10.3389/fpsyg.2014.00548

Edwards, J. R., & Lambert, L. S. (2007). Methods for integrating moderation and mediation: A general analytical framework using moderated path analysis. *Psychological Methods, 12*(1), 1–22. doi:10.1037/1082-989X.12.1.1

Elsbach, K. D., & Pratt, M., G. (2008). 4 the physical environment in organizations. *The Academy of Management Annals,* 1(1), 181-224.

Ethical Principles of the Federation of German Psychologists Associations. Requested on 28/02/2017 at https://www.dgps.de/fileadmin/documents/ Empfehlungen/ berufsethische_richtlinien_dgps.pdf.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience, 14(3)*, 340–347. doi:10.1162/089892902317361886

Fanger, P. O. (1970). *Thermal comfort: Analysis and applications in environmental engineering*. Malabar, Fla.: R.E. Krieger Pub. Co.

Farley, K. M., & Veitch, J. A. (2001). A room with a view: A review of the effects of windows on work and well-being. *Research report - 136. Institute for Research in Construction.* Canada: National Research Council.

Felsten, G. (2009). Where to take a study break on the college campus: An attention restoration theory perspective. *Journal of Environmental Psychology, 29*(1), 160–167. doi:10.1016/j.jenvp.2008.11.006

Friedman, B., Freier, N. G., Kahn Jr., P. H., Lin, P., & Sodeman, R. (2008). Office window of the future?—Field-based analyses of a new use of a large display. *International Journal of Human-Computer Studies, 66*(6), 452–465. doi:10.1016/j.ijhcs.2007.12.005

Grinde, B., & Patil, G. G. (2009). Biophilia: Does visual contact with nature impact on health and well-being? *International Journal of Environmental Research and Public Health, 6*(9), 2332–2343. doi:10.3390/ijerph6092332

Gulwadi, G. B. (2006). Seeking restorative experiences: Elementary school teachers' choices for places that enable coping with stress. *Environment and Behavior, 38*(4), 503–520. doi:10.1177/0013916505283420

Hartig, T., Böök, A., Garvill, J., Olsson, T., & Gärling, T. (1996). Environmental influences on psychological restoration. *Scandinavian Journal of Psychology, 37*(4), 378–393. doi:10.1111/j.1467-9450.1996.tb00670.x

Hartig, T., Kaiser, F. G., & Bowler, P. A. (2001). Psychological restoration in nature as a positive motivation for ecological behavior. *Environment and Behavior, 33*(4), 590–607. doi:10.1177/00139160121973142

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology, 23*(2), 109–123. doi:10.1016/S0272-4944(02)00109-3

Hartig, T., & Staats, H. (2006). The need for psychological restoration as a determinant of environmental preferences. *Journal of Environmental Psychology, 26*(3), 215–226.

doi:10.1016/j.jenvp.2006.07.007

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis*: *A regression-based approach.* New York: John Wiley & Sons.

Hayes, A. F., & Preacher, K. J. (2014). Statistical mediation analysis with a multicategorical independent variable. *British Journal of Mathematical and Statistical Psychology*, 67, 451–470. doi:10.1111/bmsp.12028

Herrmann, A., Zidansek, M., Sprott, D. E., & Spangenberg, E. R. (2013). The power of simplicity: Processing fluency and the effects of olfactory cues on retail sales. *Journal of Retailing, 89*(1), 30-43.

Herz, R. S. (2004). A naturalistic analysis of autobiographical memories triggered by olfactory visual and auditory stimuli. *Chemical Senses*, *29*(3), 217–224. doi:10.1093/chemse/bjh025

Herz, R. S. (2009). Aromatherapy facts and fictions: A scientific analysis of olfactory effects on mood, physiology and behavior. *International Journal of Neuroscience*, *119*(2), 263-290. doi: 10.1080/00207450802333953

Jahncke, H., Hygge, S., Halin, N., Green, A. M., & Dimberg, K. (2011). Open-plan office noise: Cognitive performance and restoration. *Journal of Environmental Psychology, 31*(4), 373–382. doi:10.1016/j.jenvp.2011.07.002

Jahncke, H., Eriksson, K.,& Naula, S. (2015). The effects of auditive and visual settings on perceived restoration likelihood. *Noise & Health*, *17,* 1-10.

Kahan, M., Tanzer, J., Darvin, D., & Borer, F. (2000).Virtual reality-assisted cognitive-behavioral treatment for fear of flying: Acute treatment and follow-up. *Cyber Psychology & Behavior*, *3*(3), 387-392.

Kahana, E., Lovegreen, L., Kahana, B., & Kahana, M. (2003). Person, environment, and person-environment fit as influences on residential satisfaction of elders. *Environment and Behavior, 35*(3), 434–453. doi:10.1177/0013916503035003007

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. New York: Cambridge University Press.

Kaplan, S. (1992). The restorative environment: Nature and human experience. In D. Relf (Ed.), *The role of horticulture in human well-being and social development* (pp. 134–142). Portland: Timber Press.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*(3), 169–182. doi:10.1016/0272-4944(95)90001-2

Kaplan, S., & Berman, M. G. (2010). Directed attention as a common resource for executive functioning and self-regulation. *Perspectives on Psychological Science, 5*(1), 43–57. doi:10.1177/1745691609356784

Kaplan, R., & Kaplan, S. (2011). Well-being, reasonableness, and the natural environment. *Applied Psychology: Health and Well-Being*, *3,* 304–321. doi.org/10.1111/j.1758-0854.2011.01055.x

Kärnekull, S. C., Jönsson, F. U., Larsson, M., & Olofsson, J. K. (2011). Affected by smells? Environmental chemical responsivity predicts odor perception. *Chemical Senses, 36*(7), 641–648. doi:10.1093/chemse/bjr028

Kellert, S. R., & Wilson, E. O. (Eds.). (1993). *The Biophila Hypothesis*. Covelo, Calif: Island Press.

Khalfa, S., Bella, S. D., Roy, M., Peretz, I., & Lupien, S. J. (2003). Effects of relaxing music on salivary cortisol level after psychological stress. *Annals of the New York Academy of Sciences, 999*(1), 374–376. doi:10.1196/annals.1284.045

Kjellgren, A., & Buhrkall, H. (2010). A comparison of the restorative effect of a natural environment with that of a simulated natural environment. *Journal of Environmental Psychology, 30*(4), 464–472. doi:10.1016/j.jenvp.2010.01.011

Kline, G. A. (2009). Does A View of Nature Promote Relief From Acute Pain. *Journal of*

Holistic Nursing, *27*(3), 159-166.

Knoblich, H., Scharf, A., & Schubert, B. (2003). *Marketing mit Duft*. München: R. Oldenbourg Verlag.

Korpela, K. & Hartig, T. (1996). Restorative qualities of favorite places. *Journal of Environmental Psychology,16*, 221-233.

Kuijsters, A., Redi, J., de Ruyter, B., & Heynderickx, I. (2015). Lighting to make you feel better: Improving the mood of elderly people with affective ambiences, *PLOS ONE*, *10*(7). doi:10.1371/journal.pone.0132732

Krishna, A. (2012). An integrative review of sensory marketing: Engaging the senses to affect perception, judgment and behavior. *Journal of Consumer Psychology, 22*(3), 332–351. doi:10.1016/j.jcps.2011.08.003

Largo-Wight, E. (2011). Cultivating healthy places and communities: evidenced-based nature contact recommendations. *International Journal of Environmental Health Research*, *21*, 41-61.

Laumann, K., Gärling, T., & Stormark, K. M. (2003). Selective attention and heart rate responses to natural and urban environments. *Journal of Environmental Psychology, 23*(2), 125–134. doi:10.1016/S0272-4944(02)00110-X

Lederbogen, F., Kirsch, P., Haddad, L., Streit, F., Tost, H., Schuch, P. et al. (2011). City living and urban upbringing affect neural social stress processing in humans. *Nature, 474*, 498–501.

Lee, K. E., Williams, K. J. H. Sargent, L. D. Williams, N. S. G. & Johnson, K. A. (2015). 40-second green roof views sustain attention: The role of micro-breaks in attention restoration. *Journal of Environmental Psychology*, *42*, 182-189.

Lohmann-Haislah, A. (2012). *Stressreport Deutschland 2012: Psychische Anforderungen, Ressourcen und Befinden*. Dortmund [u.a.]: Bundesanstalt für Arbeitsschutz und Arbeitsmedizin.

Magjarevic, R., Nagel, J. H., Vander Sloten, J., Verdonck, P., Nyssen, M., & Haueisen, J. (Eds.). (2009). *IFMBE Proceedings*. *4th European Conference of the International Federation for Medical and Biological Engineering*. Berlin, Heidelberg: Springer.

Marselle, M. R., Irvine, K. N., Lorenzo-Arribas, A., & Warber, S. L. (2016). Does perceived restorativeness mediate the effects of perceived biodiversity and perceived naturalness on emotional well-being following group walks in nature? *Journal of Environmental Psycholog*y, *46*, 217-232. doi:10.1016/j.jenvp.2016.04.008

Mattila, A. S., & Wirtz, J. (2001). Congruency of scent and music as a driver of in-store evaluations and behavior. *Journal of Retailing*, *77*(2), 273–289. doi:10.1016/S0022-4359(01)00042-2

McCoy, J. M., & Evans, G. W. (2002). The potential role of the physical environment in fostering creativity. *Creativity Research Journal*, *14*(3-4), 409–426. doi:10.1207/S15326934CRJ1434_11

McNair, D.M., & Lorr, M. (1964). An analysis of mood in neurotics. *Journal of Abnormal and Social Psychology*, *69*, 620-627.

Michon, R., Chebat, J.-C., & Turley, L. W. (2005). Mall atmospherics: the interaction effects of the mall environment on shopping behavior, *Journal of Business Research*, *58*, 576-583. doi:10.1016/j.jbusres.2003.07.004

Nitsch, J. R. (1976). Die Eigenzustandsskala (EZ-Skala) – Ein Verfahren zur hierarchisch mehrdimensionalen Befindlichkeitsskalierung. In J. R. Nitsch & I. Udris (Eds.), *Beanspruchung im Sport. Beiträge zur psychologischen Analyse sportlicher Leistungssituation* (pp. 81–102). Bad Homburg: Limpert.

Nitsch, J. R., & Udris, I. (Eds.). (1976). *Beanspruchung im Sport: Beiträge zur* psychologischen Analyse sportlicher Leistungssituation. Bad Homburg: Limpert.

Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation, *Psychological Methods*, *15*, 209–233.

Ragland, J. D., Turetsky, B. I., Gur, R. C., Gunning-Dixon, F., Turner, T., Schroeder, L., Chan, R., & Gur, R. E. (2002). Working memory for complex figures: An fMRI comparison of letter and fractal n-back tasks. *Neuropsychology, 16*(3), 370–379. doi:10.1037/0894-4105.16.3.370

Ramic-Brkic, B., Chalmers, A. G., Boulanger, K., Pattanaik, S., & Covington, J. (2009). Cross-modal effects of smell on the real-time rendering of grass. In Spring Conference on Computer Graphics SCCG '09: *Proceedings of the 25th Spring Conference on Computer Graphics*, 175-179. New York: ACM Press.

Ratcliffe, E., Gatersleben, B., & Sowden, P. T. (2013). Bird sounds and their contributions to perceived attention restoration and stress recovery. *Journal of Environmental Psychology*, *36,* 221–228. doi:10.1016/j.jenvp.2013.08.004

Richter, P. G. (2009). *Architekturpsychologie: Eine Einführung*. Lengerich: Pabst Science Publishers.

Russell, J. A. (2003). Core affect and the psychological construction of emotion. *Psychological Review*, *110*(1), 145–172. doi: 10.1037/0033-295X.110.1.145

Sonnentag, S. & Fritz, C. (2015). Recovery from job stress: The stressor-detachment model as an integrative framework, Journal of Organizational Behavior, *36*(1), 72–103, doi: 10.1002/job.1924

Sonnentag, S. (2012). Psychological detachment from work during leisure time: The benefits of mentally disengaging from work, *Current Directions in Psychological Science*, *21*(2), 114–118. doi: 0.1177/0963721411434979

Sonnentag, S., Binnewies, C., & Mojza, E. J. (2011). Staying well and engaged when demands are high: The role of psychological detachment, *Journal of Applied Pychology*, *95*(5), 965-976. doi:10.1037/a0020032

Sonnentag, S. (2010). Recovery from fatigue: The role of psychological detachment. In P. L. Ackerman (Ed.), Cognitive fatigue: The current status and future for research and application (pp. 253–272). Washington, CD: American Psychological Association. doi: 10.1037/12343-012

Sonnentag, S., & Fritz, C. (2007). The recovery experience questionnaire: Development and validation of a measure for assessing recuperation and unwinding from work. *Journal of Occupational Health Psychology, 12*(3), 204–221. doi:10.1037/1076-8998.12.3.204

Spangenberg, E. R., Crowley, A. E., & Henderson, P. W. (1996). Improving the store environment: Do olfactory cues affect evaluations and behaviors? *Journal of Marketing, 60*(2), 67–80. doi:10.2307/1251931

Staats, H., & Hartig, T. (2004). Alone or with a friend: A social context for psychological restoration and environmental preferences. *Journal of Environmental Psychology, 24*(2), 199–211. doi:10.1016/j.jenvp.2003.12.005

Staats, H., Kieviet, A., & Hartig, T. (2003). Where to recover from attentional fatigue: An expectancy-value analysis of environmental preference. *Journal of Environmental Psychology*, *23*(2), 147–157. doi:10.1016/S0272-4944(02)00112-3

Steg, L., van den Berg, A., & de Groot, J. I. M. (2012). *Environmental Psychology: An Introduction.* BPS Blackwell.

Trougakos, J. P., Beal, D. J., Green, S. G., & Weiss, H. M. (2008). Making the break count: An episodic examination of recovery activities, emotional experiences, and positive affective displays. *Academy of Management Journal, 51*(1), 131–146. doi:10.5465/AMJ.2008.30764063

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman & J. F. Wohlwill (Eds.), *Behavior and the Natural Environment* (pp. 85–125). Plenum Press, New York.

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science, 224*(4647), 420–421. doi:10.1126/science.6143402

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991).

Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*(3), 201–230. doi:10.1016/S0272-4944(05)80184-7

Ulrich, R. S. (1993). Biophilia, biophobia, and natural landscapes. In S. R. Kellert & E. O. Wilson (Eds.), *The Biophila Hypothesis* (pp. 73–137). Covelo, Calif: Island Press.

Urlaub, S., Hellwig, R.T., van Treeck, C., & Sedlbauer, K. (2010). Möglichkeiten und Grenzen bei der Modellierung von Einflussfaktoren auf die menschliche Leistungsfähigkeit [Possibilities and limitations of modelling factors influencing human performance]. *Bauphysik*, 32(6), 373-379.

Vischer, J. C. (2007). The effects of the physical environment on job performance: towards a theoretical model of workspace stress. *Stress and Health, 23*(3), 175–184. doi:10.1002/smi.1134

Wiederhold, B. K., Gao, K. Sulea, C., & Wiederhold, M. D. (2014). Virtual reality as a distraction technique in chronic pain patients, *Cyberpsychology, behavior and social networking*, *17*(6), 346-352. doi:10.1089/cyber.2014.0207

White, M., Smith, A., Humphryes, K., Pahl, S., Snelling, D., & Depledge, M. (2010). Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes. *Journal of Environmental Psychology*, *30*, 482–493. doi:10.1016/j.jenvp.2010.04.004

Yoye, Y., & Bolderdijk, J. W. (2015). An exploratory study into the effects of extraordinary nature on emotions, mood, and prosociality, *Frontiers in Psychology*, *5*, 1577-1586.

Table 1

Overview of experimental conditions.

Control group	Nature condition	Lounge condition	Scented nature condition	Scented lounge condition
n = 23	*n* = 25	*n* = 25	*n* = 27	*n* = 22
no window no scent/ neutralizer no sound	window ‘nature’ no scent/ neutralizer bird sound	window ‘lounge’ no scent/ neutralizer instrumental music	window ‘nature’ congruent scent bird sound	window ‘lounge’ congruent scent instrumental music

Table 2

Perception of the break room and personal resources: Descriptives and Results of the Manipulation Check.

	Control group	**Unscented Nature**	**Unscented Lounge**	**Scented Nature**	**Scented Lounge**	**Results of the Manipulation Check (ANOVA)**					
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	Main effect time		Main effect Condition		Interaction Effect	
						F	η_p^2	*F*	η_p^2	*F*	η_p^2
Fatigue						45.24**	.28	1.03	.04	1.99	.06
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)						
Feelings of Restoration						16.12**	.12	.38	.01	1.30	.04
t1	4.35 (0.72)	4.31 (1.02)	4.35 (0.82)	4.17 (0.95)	4.52 (0.85)						
t2	4.01 (0.92)	4.06 (0.81)	4.30 (0.90)	3.95 (1.03)	3.97 (0.94)						
t3	4.57 (0.74)	4.58 (0.76)	4.82 (0.64)	4.60 (0.73)	4.67 (0.81)						
Mood						12.07*	.09	.25	.01	2.77*	.09
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						4.28*	.04	1.19	.04	.62	.02
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)						
Self-control capacity						57.67*	.33	.83	.03	2.46*	.08
t1	4.97 (0.75)	5.00 (0.67)	5.04 (0.54)	4.97 (0.59)	4.97 (0.75)						
t2	4.33 (1.11)	4.59 (0.78)	4.82 (0.68)	4.64 (0.98)	4.21 (0.99)						
t3	4.84 (0.84)	5.06 (0.53)	5.09 (0.55)	5.08 (0.60)	4.88 (0.91)						
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)						
Perceived Restorativeness	3.21 (0.98)	3.89 (0.89)	3.50 (1.05)	3.93 (0.83)	3.68 (0.81)						

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

Table 3

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	…Odour	.02	-.05	.08	.18^{+}	.16	.21*		
4	Restorativeness	.35**	.19	.18^{+}	.07	57**	.41**	.35**	
	Personal resources								
	… Feelings of restoration	-.01	.15	.00	.04	.19^{+}	.28**	.23*	.44**
	… 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*
	… Self-control capacity	.15	.02	.07	.04	.26*	.17^{+}	.23*	.38**

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/restorativeness 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 4

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
SMM1	Feelings of restoration	120	.10	-.09	.56*	.34**			.19	.09	.05	.34
	Fatigue	120	-.16	-.06	.50*	-.19**			-.10	.06	-.20	-.02
	Mood	120	.09	-.09	.55*	.33**			.18	.09	.05	.33
	Arousal	120	.02	.20	.54*	-.33**			-.18	.11	-.38	-.03
	Self-control capacity	120	.10	.01	.55*	.17**			.09	.04	.03	.17
SMM2	Feelings of restoration	97	.01	-.04	.16^{+}	.34**			.06	.03	.004	.11
	Fatigue	97	-.03	.01	.17^{+}	-.21*			-.04	.02	-.08	-.003
	Mood	97	.05	.00	.17^{+}	.32**			.05	.03	.009	.11
	Arousal	97	-.40	-.28	.33^{+}	-.37*			-.12	.09	-.28	.00
	Self-control capacity	97	.04	.01	.16^{+}	.19**			.03	.02	.002	.06
SMM3	Feelings of restoration	89	.08	.07		.32**	.47^{+}	.24**	.02	.01	.0004	.04
	Fatigue	89	-.10	-.06		-.19*	.50^{+}	.24**	-.01	.01	-.06	-.0003
	Mood	89	.28^{+}	.28*		.35**	.51^{+}	.24**	.02	.02	.001	.05
	Arousal	89	.30	.34		-.38*	.52^{+}	.24**	.02	.01	-.13	-.0001
	Self-control capacity	89	.09	.07		.21**	.54^{+}	.25**	.01	.01	.002	.03

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*) are unstandardized. All models free from multicollinearity (all VIF ≤ 4.0). $^{+}$ $p < .10$ (one-sided), * $p < .05$, ** $p < .01$.
Path *a*: independent variable on PRS; path *b*: PRS 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 PRS. SMM1: First mediation model, tested whether SEBEs promoted personal resources through perceived restorativeness (H1a and H1b). SMM2: Second serial mediation model, tested whether the simulated environment promoted perceived restorativeness (H3b). SMM3: Third sequential mediation model, tested whether SEBEs with congruent scents were linked to personal resources through the sequential mediation of perceived scent pleasantness and perceived restorativeness (H4b).

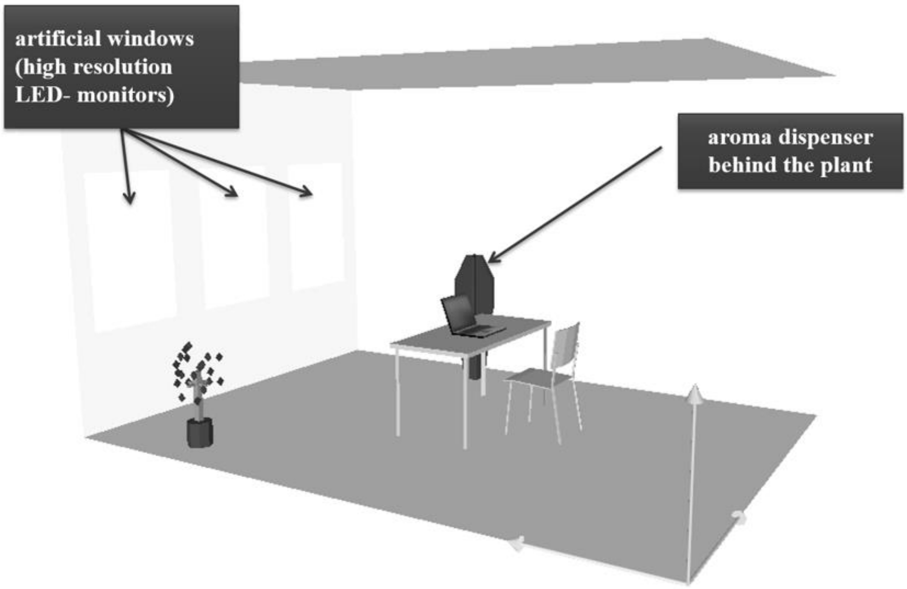


Fig. 1. Simulation of the break room with artificial windows and aroma dispenser.

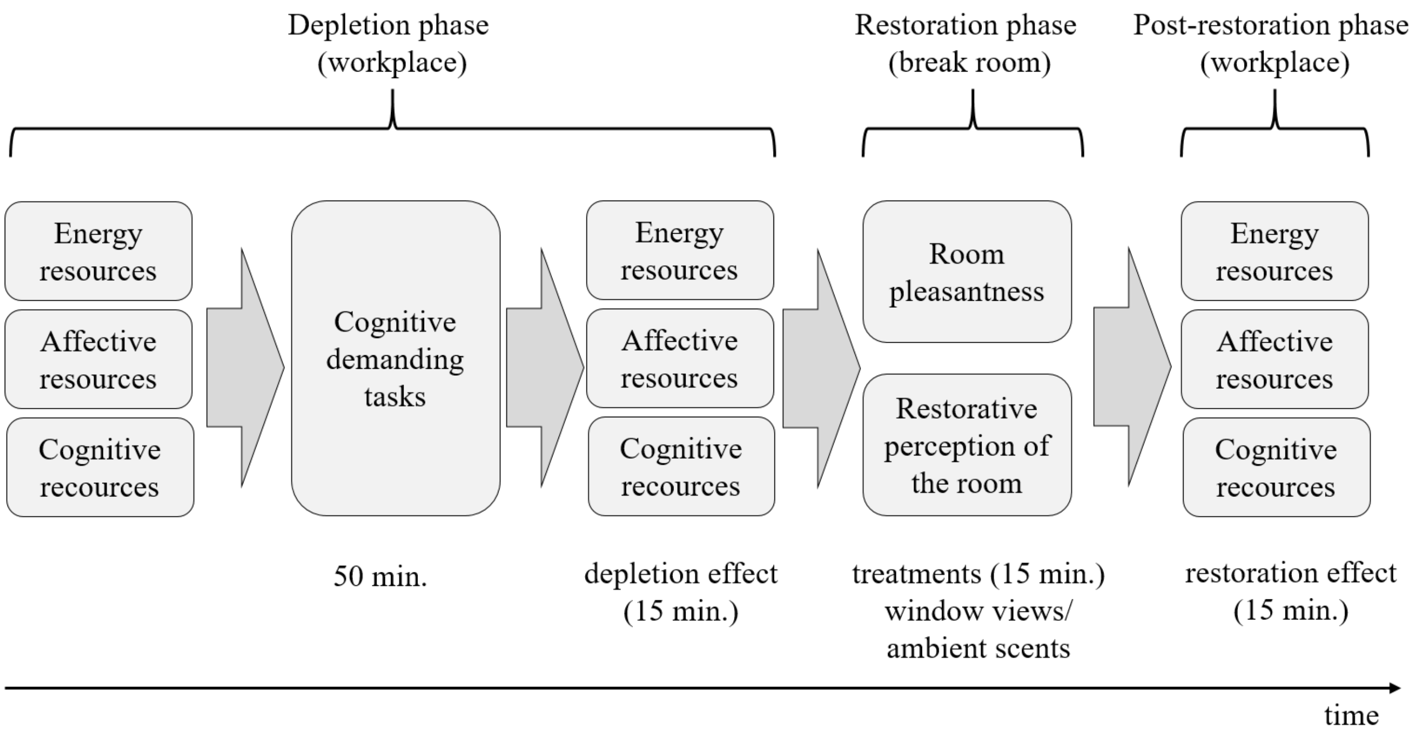


Fig. 2. Overview of procedure.

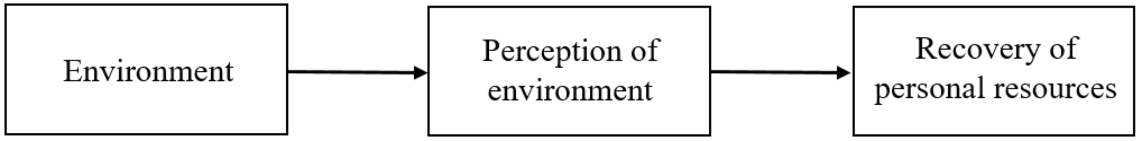


Fig. 3. Conceptual Model. Hypothesized causal chain of physical environment on recovery of personal resources through perception of environment.

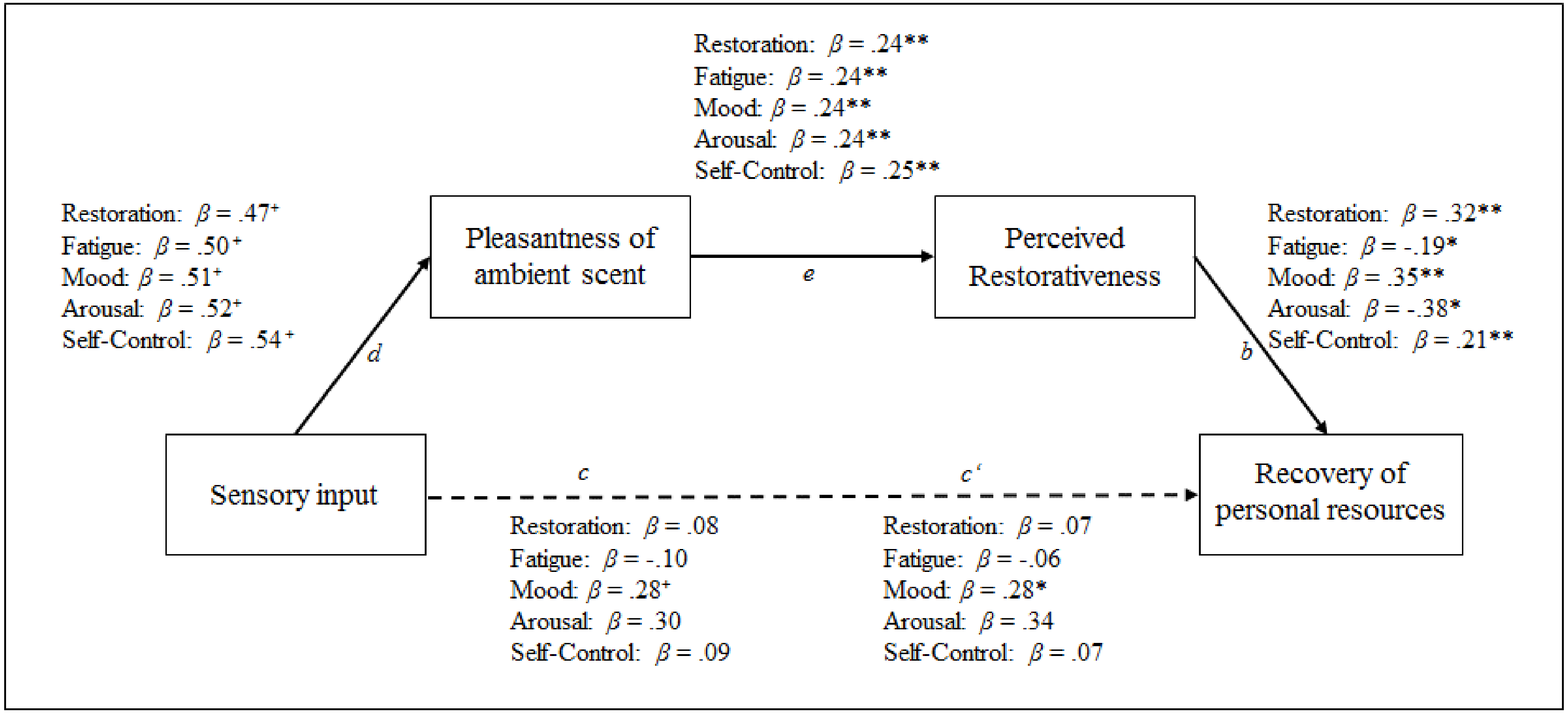


Fig. 4. SMM 3. Scented conditions (= 1) vs. unscented conditions excluding control group (= 0) on personal resources (feelings of restoration, mood, subjective arousal, and self-control) are mediated by pleasantness of ambient scent (path d), followed by perceived restorativeness. *N* = 118. *c* = direct 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.

Supplemental Materials: Additional Details of Procedures and Analyses

Table S1. Perception of the break room conditions. Descriptives.

Independent Variable	**Control group**	**Unscented Nature**	**Unscented Lounge**	**Scented Nature**	**Scented Lounge**
Dependent Variable	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Physical comfort					
…Temperature	4.50 (2.14)	5.43 (1.57)	5.00 (1.88)	5.46 (1.69)	4.83 (2.08)
…Air quality	5.44 (1.17)	5.26 (1.11)	5.24 (1.26)	5.42 (1.32)	5.42 (1.12)
… Lighting	4.05 (1.70)	5.00 (1.52)	4.87 (1.21)	5.18 (1.05)	4.90 (1.33)
… Acoustics	4.22 (1.82)	4.70 (1.84)	5.10 (1.59)	5.14 (1.64)	5.03 (1.82)
Pleasantness					
…View	3.00 (2.00)	6.45 (.89)	4.68 (1.89)	6.35 (1.34)	4.50 (1.64)
…Sound	3.21 (1.40)	5.10 (1.48)	4.68 (1.70)	5.18 (1.70)	5.50 (1.47)

Physical Conditions in the Rooms. Temperature in both rooms was set to 23 Celsius degree for all conditions with the air conditioner system from Siemens Typ PXM 20. As a supplement to this air conditioning, we used in both laboratories also wall and ceiling heating systems. Additionally, we measured room temperature before starting the study and once during the experiment with a portable temperature measuring instrument (Almemo 2890-9 from Ahlborn). Moreover, constant, congruent lighting conditions were simulated via a central lighting control system providing direct as well as indirect lighting scenarios. The office room provided neutral-white light of 2043 lx (vertically measured at eye-level) and the break room warm-white light of 1477 lx.

Auditory Material. The used music of nature is from the CD: “Wohltuende Waldstimmung”: Heilsame Naturklänge zum Loslassen, Wohlfühlen und Entspannen“, Song 1: “Der Wald erwacht” from Neptun); the used instrumental music is an instrumental version of „Smiles Anew“ and „Nuthin‘ but a „G“ Thang“) (see also Khalfa, Bella, Roy, Peretz, and Lupien, 2003).

Fig. S1. Restoration room environments. Left: Lounge scenario. Right: Nature scenario.

Chapter 4: A contribution to theory testing: Transferring restorative environments into the work context

Powered by Virtual Realities:

The Impact of Immersion in Soft and Spectacular Nature on Emotional Recovery

Brid Sona & Anna Steidle

Abstract

How can virtual nature improve well-being? Previous research indicates the impact of perceived realism and the presented nature itself. Hence, we tested the effects of nature exposure with different degrees of immersion (laptop screen with 360° video player vs. head mounted displays, HMDs) and types of environments (soft vs. spectacular nature) for recovery during work breaks. ‘Soft’ contains relaxing scenes, whereas ‘spectacular’ includes extraordinary scenes. Data were collected from academics (*n* = 56), white-collar workers (*n* = 101) and night-shift blue-collar workers (*n* = 26), testing three hypotheses: (1) HMD nature might be perceived as more restorative than the laptop condition, which might indirectly increase positive and decrease negative affect. (2) Soft nature might help to calm down, while experiencing spectacular nature might lead to stimulation. (3) Spectacular nature might be more fascinating than soft nature, which might indirectly increase positive and decrease negative affect. The results for academics and white-collar workers mainly support these assumptions, while results among the nightshift workers only confirm the restorative perception. This research points out the benefits of ‘virtual breaks’ for recovery. Rapid progress in technology will allow the development of even more adaptable HDMs, which will finally cross the boundary from ‘artificial’ to ‘brave new’ worlds.

Keywords: virtual realities, recovery, micro breaks, immersion, stimulation, calming

Introduction

Virtual environments and realities (VR) have become increasingly 'natural' in our everyday life, e.g., watching television or online gaming. Now they are entering the area of recovery. Although individuals generally prefer contact with real rather than artificial environments (Hartig & Staats, 2006), several studies confirm the restorative value of virtual nature (Felsten, 2009; Friedman et al., 2008; Kjellgren and Buhrkall, 2010, Largo-Wight 2011) and both may be perceived as almost similarly restorative. Recovery can be defined as the replenishment of an individual's depleted resources (Sonnentag & Zijlstra, 2006). For optimal well-being and performance at work, individuals need to take breaks to support short-term recovery. Studies showed that even a very brief (40 sec–10 min.) exposure to (virtual) nature can trigger recovery, with manifestations including increases in positive mood (Depledge, Stone & Bird, 2011; Lee, Williams, Sargent, Williams & Johnson, 2015; Berto, 2005).

Virtual presentations of nature may provide an effective means to enable contact with nature for people unable to visit real nature (e.g. people with impaired mobility), at places without access to nature (e.g., in large cities or underground), or at times when nature is not readily accessible (e.g., at night or during bad weather; Depledge et al., 2011). VRs offer access to any kind of environment to refill depleted resources in a very time- and cost-efficient way. With the aid of VR, even nightshift workers may experience artificial sunlight, a boat journey on a river, or a flight over a landscape during their work breaks.

Until now, the question has remained open as to what degree of immersion of a simulated environment is actually needed. The present research aims to contribute to this question by investigating the role of technical presentation devices and the immersion into nature environments associated with them (Kjellgren & Buhrkall 2010, de Kort & IJsselsteijn 2006). Moreover, the present research contributes to clarifying the role of the presented environment itself. So far, restoration research has predominantly investigated calming natural environments and it is not yet completely clarified whether stimulating environments have an equally positive impact on recovery. However, there are some first indications that stimulating environments may also foster emotional recovery (Joye & Bolderdijk, 2015; Kuijsters et al., 2015). Hence, this research will investigate unique benefits of stimulating and calming natural environments on emotional recovery. Apart from that, previous studies have requested mediation analyses to clarify how environmental qualities influence human's health (e.g., Sandifer, Sutton-Grier & Ward, 2015). Thus, the current research will also outline more closely the psychological pathway from the restorative quality of an environment to concrete recovery outcomes.

The relevance of immersion

The restorative benefits of nature have been widely researched (for a recent overview see Hartig, Mitchell, de Vries, & Frumkin, 2014) and exposure to both real and artificial nature can foster recovery (for an overview see Beute & de Kort, 2014b). The technological devices used to create a virtual nature experience may largely influence how real or artificial the environment is perceived as being. In this context, a distinction can be made between the degree of *immersion,* which Slater & Wilbur (1997) define "as an objective property of the technology," and *presence,* which they define "as a psychological reaction to this technological property" (Grimshaw, 2014, p.224). New technologies like HMDs might create stronger immersion than traditional screen views: as the head is turned the perspective of the scene synchronically changes; looking down, one might see one's own body as a part of the virtual environment (Grimshaw, 2014). Hence, users are drawn more easily into the scene with HMDs and may perhaps perceive and respond in a better way.

Past research has shown that the degree of immersion provided by HMDs influenced distraction from pain perception. For instance, participants viewing a *SnowWorld* in a highly immersive VR experienced 34% more reduction in pain, they thought 29% less about their pain, and they experienced 32% more enjoyment during pain than participants in a low immersive

VR (Hoffman et al., 2011). Another study found benefits from a high (vs. low) immersive screen showing a nature film for physiological restoration after inducing stress (de Kort et al., 2006).

To explain the restorative effect of nature, Kaplan (1995) presents four components that are crucial for environments for fostering recovery and which can be measured by applying the *Perceived Restorativeness Scale* (*PRS*; see also Berto, 2005; Felsten, 2009; White et al., 2010). The four components are: (1) F*ascination*: Berto, Baroni, Zainaghi, & Bettella (2010) argue that "attentional fatigue can be renewed in environments where fascinating stimuli are present as they evoke effortless attention and allow directed attention to rest and be restored"(p.494). (2) *Being away:* Being away emphasizes a distance in a mental or spatial way; (3) *Coherence*: It proposes that there should be a congruency between all sensory impressions; and (4) *Compatibility*: It involves a fit between environment and personal requirements.

Stress recovery theory (SRT, Ulrich et al., 1991) assumes that nature enhances positive affect respectively decreases negative affect (Berman et al., 2008; Hartig et al., 2003; Ulrich et al., 1991). In particular, humans prefer natural environments that provide resources (e.g., availability of nutrition, non-threatening places; Ulrich et al., 1991).

In addition, previous research has postulated a positive link between perceived restorativeness and positive affect (Hartig et al., 1997; Marselle et al., 2015). Moreover, it has been shown that the effect of perceived naturalness on positive affect is mediated by PRS (Marselle et al., 2016). Further, fascination mediates the link between nature experience per day and positive affect (Sato & Conner, 2013). According to these previous findings, we assume for VRs that the perceived restorativeness of the environment and emotional recovery may increase with higher degrees of immersion. Moreover, we postulate that perceived restorativeness mediates the link between HMD presentation and emotional recovery. In sum, we expected:

Hypothesis 1. Compared to a laptop screen presentation, the presentation of a nature scene presented via HMD should increase the perceived restorativeness of the environment (H1a), which should indirectly increase positive affect (H1b) and decrease negative affect (H1c), see Fig. 1).

Different types of nature for calming vs. stimulating

VRs can present different types of natural environments, which have specific effects on emotional recovery. Previous restoration research has shown that mundane nature (e.g., parks or gardens) promotes the recovery of depleted cognitive and emotional resources since it is softly fascinating (Kaplan and Kaplan, 1989; Ulrich et al., 1991; Kaplan, 1995; Kaplan and Berman, 2010). In particular, mundane nature reduces arousal and increases positive affect (Beute, & de Kort, 2014a/b; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Kaplan and Berman, 2010, Kaplan, 1995; Kaplan and Kaplan, 1989; Kuijsters et al., 2015). In the current paper, the terminus ‘soft nature’ is introduced. Soft nature also implies a reduction in arousal and an increase in positive affect and is classified as a calming nature setting, as mundane nature (adapted from Joye & Bolderdijk, 2015). However, soft nature (e.g., a softly fascinating landscape in Ireland) represents a natural environment which is not as omnipresent as mundane nature.

In contrast, spectacular (or extraordinary) nature scenes (e.g., impressive mountain scenes or awesome waterfalls) are characterized as high in emotional intensity, triggered by overwhelming impressions (Joye & Bolderdijk, 2015). Hence, spectacular nature should elicit higher arousal levels as well as positive affect and could be classified as a stimulating environment. We assume that this kind of nature should elicit a higher degree of fascination.

Little research is available on spectacular nature, since it has been assumed that only soft fascination (a low to moderate level of arousal) would foster recovery processes whereas a higher degree of fascination would lead to high levels of arousal, which might be a barrier to recovery (Kaplan, 1995; Kaplan & Berman, 2010). However, a recently conducted study indicates the value of spectacular nature for recovery, with the reasoning that spectacular and mundane nature may lead to differing mood patterns and behavior intentions (Joye & Bolderdijk, 2015). In particular, watching a slideshow of either mundane or spectacular nature scene improved mood, while a neutral slide show did not affect mood. More importantly, mood improvement was stronger for spectacular nature compared to mundane nature.

Hence, different nature scenes may provoke specific mood patterns depending on their calming or stimulating level. Mood can here be understood as a two-dimensional construct with valence (negative vs. positive) and arousal (low vs. high sense of mobilization and energy) as bipolar dimensions (Russell, 2003). A *stimulating effect* can be described as a combination of *(1) an increase in high arousing, positive mood* and *(2) a decrease in low arousing, negative mood*, whereas a *calming effect* can be described as a combination of *(1) an increase in low-arousing, positive mood* and *(2) a decrease in high-arousing, negative mood.* In particular, we expected:

Hypothesis 2: Soft nature should evoke calming effects rather than stimulation (H2a), whereas spectacular nature should evoke stimulation rather than calming effects (H2b, see Fig. 2).

Adapted from Joye & Bolderdijk (2015) showing that 'awe' is a mediator of mood, and Berto et al. (2010) showing the crucial role of high fascination on attentional recovery, we expected the following psychological pathway from the restorative quality of an environment to concrete recovery outcomes:

Hypothesis 3: Spectacular nature is perceived as more fascinating than soft nature, which should indirectly increase positive affect (H3a) and decrease negative affect (H3b, see Fig. 3).

Study 1

In Study 1, we tested the effects of different nature VRs in an academic sample using a between-subject design.

Methods

Ethics Statement. Our research project stays in line with the *Ethical principles of psychologists and code of conduct* (American Psychological Association, 2002). The present studies do not constitute critical aspects of law (e.g., medical acts), nor compromise the anonymity of subjects. All participants were made aware of study procedure before participation, acted voluntarily, and could cancel the study at any time. The participation started after verbal consent was given. Ethics approval is not required if the foregoing criteria do not apply to the current research.

Subjects. 56 academics participated in the study. Five subjects were excluded from further analysis due to technical and contextual disturbances (e.g., video out of focus, noise). The final sample comprised 51 individuals (17 women; mean age 22.82 years, SD = 3.15, range: 18 - 33). The sample of academics was chosen because these academics have to spend much of their working time inside buildings, e.g., work on the computer, and have no time to go to natural environments in their short work breaks. Therefore, they might benefit from the present intervention. Participants were randomly assigned to one of three VR interventions.

Intervention conditions. Participants saw a 3-minute virtual reality presentation of nature with 360° perspective. The presentations used varied in terms of immersion (laptop screen vs. HMD) and in terms of simulated environment (soft vs. spectacular nature). The three conditions were labeled ‘Laptop soft nature,’ ‘HMD soft nature,’ and ‘HMD spectacular nature.’

The nature videos were presented either using a laptop (screen 15.6-inch-screen; 2880 x 1440 pixels) or using an HMD (*Samsung Gear VR;* hardware from *Oculus*; hardware from *Samsung Galaxy Note 4*; 2880×1440 pixels; 60 fps; h264 container with a bit rate of 40 Mb/s).

The free video player *Kolor Eyes 1.4* was used to play the 360-degree video on the laptop. Participants in the laptop condition were able to rotate the environment using a mouse. In contrast, the HMD groups could rotate within the environment via their head and body movements and the swivel chair on which they were seated. The HMD could also be used by participants with vision impairments, since the diopter setting can be changed using a small wheel. Headsets provided participants with auditory stimuli via headphones.

Laptop soft nature / HMD soft nature. The soft nature video was used on the laptop screen and on HMD. Overall, the soft nature video should induce rather calming than stimulating because the used scenes were static, that is, the camera itself did not move and the scenes changed every 30 seconds. Thus participants had enough time to view the whole environment, but they could not move through the VR. The video ("*Ireland VR",* 2015) was produced and provided by the company *Atmosphaeres* and showed various natural landscapes in Ireland merginf into one another.

The video begins with a view of a small stream flowing into the sea from among rocky banks. Participants could hear the flowing water and birdcalls. Looking backwards, participants could see the course of the small stream and a green field. About 30 sec. later, the perspective changes to a location closer to the sea. The scene shifts to a green forest including another stream. Looking upwards, the video shows a blue sky with some white clouds, while looking down it shows the forest floor with stones, moss and rippling water. It ends with a view of a tranquil lake and a sunrise. The video is supported by calming natural sounds (including rippling water and birdsong; Alvarsson, Wiens, & Nilsson, 2010).

HMD spectacular nature. The spectacular nature video should induce rather stimulating than calming because the used scenes were not static. Hence, the camera moved so that participants also moved through the VR and had only little time to view the whole scene. The video, ("Africa Safari," available from the *Oculus Store*), showed a series of safari scenes in

Kenya which merged into one another. The video begins with a sunrise, continues with a helicopter flight over grazing animals (including zebras) and a lake where elephants are bathing, shows lions lying in the shade, and ends with an elephant ride in the sunset. The video is supported by stimulating instrumental music (including African drumming). For all three conditions, directly after the intervention, participants rated their feeling of sickness (1 = a little sick – 6 = extremely sick). Most participants did not feel sick (80.4% not at all; 15.7% a little; 2% to some extent).

Procedure. The study was conducted in 2016 and ran for three days from 10 am to 5 pm. The location of the study was a lab room. Sessions contained up to four participants, separated by sight protection. Upon arrival, participants were informed of the purpose and the duration of the study (10 minutes). Participants were asked for their current affect, which served as a baseline measure of the participant's affective resources. Experimenters instructed participants in the handling of the HMD and laptop and started the VR nature experiences. After the intervention, participants answered questions regarding perceived restorativeness during the intervention and again assessed their current affect.

Measures. The perception of the restorative quality of the VR was assessed using a short version of the Perceived Restorativeness Scale (PRS; Hartig et. al., 1996; adapted from Berto, 2005) which entails the four dimensions of Attention Restoration Theory (ART) and is frequently used in attention restoration literature (e.g., Berto, 2005; Felsten, 2009; White et al., 2010). Four items were answered on a six- point Likert-scale (1 = little – 6 = extremely) and belong to four subscales: fascination ("The nature video was fascinating and there was much to discover."), compatibility ("In the nature video, I could move freely and do what I want."), coherence ("The nature video was confusing and chaotic.") and being away ("During the nature video I forgot my work and was relaxed."). We built an overall score of PRS by averaging the respective items.

To assess restoration effects, affective resources were assessed using subjective assessments. Building on the conceptual model of core affect (Russell & Barrett, 1999; Yik, Russell, & Steiger, 2011), four affective states were assessed with differing pleasantness and arousal: pleasant-activated (PA), unpleasant-activated (UA), pleasant-deactivated (PD), and unpleasant-deactivated (UD). Three adjectives representing each of the four dimensions were selected following Sonnentag, Binnewies, & Mojza (2008). Items for the PA affect ("alert," "happy," "active") and UA affect ("nervous," "tense," "afraid") stem from *Positive and Negative Affect Schedule (PANAS*, Watson, Clark, & Tellegen, 1988).

PD and UD affect was assessed via three items adapted from the construct *Serenity* (Abele-Brehm & Brehm, 1986; "calm," "relaxed," "content") and from the Profiles of Mood Scales (POMS; McNair, Lorr, & Droppelman, 1971; "exhausted," "sad," "disappointed"). To assess the amount of positive and negative affect, the means of the respective items were calculated. To assess the amount of stimulation, the increase in low-arousing, negative mood was subtracted from the increase in high-arousing, positive mood. To assess the amount of calming, the increase in high-arousing, negative mood was subtracted from the increase in low-arousing, positive mood.

Data Analysis. To test the postulated hypotheses, we conducted correlation analyses, variance analyses and mediation analyses with ordinary least squares regression and 10000 bootstrap samples using model 4 of PROCESS macro version 2.13 from Hayes (2013; procedures by Edwards & Lambert, 2007). We tested all indirect effects as directed hypotheses (one-tailed $\alpha = .05$; 90% bias-corrected bootstrap confidence interval; hypotheses are confirmed if the confidence interval did not include zero, Preacher, Zyphur, and Zhang, 2010). For the mediation of hypothesis 1, we used the following dummy coding: HMD = 1, laptop screen = 0. For the mediation of hypothesis 3, we used the following dummy coding: HMD spectacular nature= 1, HMD soft nature = 0. Consistent with previous studies (Joye & Bolderdijk, 2015), we included the measurement of affect before treatment (t1) as a covariate in all analyses of affect to control for differences between conditions.

Results

The effect of immersion. Table 1 presents descriptive statistics, correlations and reliabilities of all relevant variables. Analyses were tested for HMD conditions vs. laptop condition (dummy coded: HMD = 1, laptop = 0). As expected, the analyses yielded significant effects on PRS (b = 1.26, $p < .01$) indicating that the HMD conditions were perceived as more restorative compared to the laptop condition. Testing the postulated mediation, higher PRS led to significant increases in positive affect (indirect effect = .59, *SE* =.19, 95% *CI* [.23, .98]), and significant decreases in negative affect (indirect effect = -.35, *SE* =.15, 95% *CI* [-.68, -.11]), which confirmed the mediation hypothesis of PRS on emotional recovery. Thus, H1a, H1b and H1c were supported.

The effect of different types of nature for calming vs. stimulating. Table 2 presents descriptive statistics and reliabilities for all relevant variables. A 2 (type: HMD soft vs. HMD spectacular) x 2 (energy: stimulating vs. calming)-mixed model ANOVA revealed no significant main effect of energy, $F(1,30) = .00$, $p = .98$, $\eta^2 = .00$, but, more importantly, a significant interaction, $F(1,30) = 8.42$, $p < .01$, $\eta^2 = .22$). Paired t-tests showed that the calming effect was stronger than the stimulating effect in the soft nature condition, $t(15) = -2.40$, $p < .05$, while the stimulating effect was marginally stronger than the calming effect in the spectacular nature condition, $t(15) = 1.83$, $p < .10$. Thus, the results confirm H2a and H2b.

Testing the postulated mediation, for HMD spectacular nature, higher fascination did not lead to increases in positive affect (indirect effect = .08, *SE* =.08, 90% *CI* [-.06, .20]), but higher fascination led to significant decreases in negative affect (indirect effect = -.06, *SE* =.04, 95% *CI* [-.16, .00], 90% *CI* [-.14, -.01]). Thus, H3a was rejected, whereas H3b was confirmed.

Study 2

In Study 2, we tested the effects of various nature VRs on a white-collar worker (office worker) sample using a between-subject design.

Methods

Ethics Statement, intervention conditions, measures, measurement procedure, and analytic strategy were the same as in Study 1.

Subjects. 101 employees (53 women; mean age 39.36 years, SD =9.61, range: 23 - 63) voluntarily participated in the study. Two participants were excluded from further analyses due to sickness caused by the HMD. The sample of these employees was chosen because they spend their entire working day inside a building. They have no possibility to go in natural environments during their break times, since the building is located in a large city. Hence, they might benefit from the present intervention.

Procedure. The study was conducted in 2016 and ran for five days from 10 am to 5 pm. Over the five days, participants took part in one of the micro break interventions (between-subject design). The intervention was conducted in a common-room next to the work place. Three individuals could participate simultaneously in the study.

Results

The effect of immersion. Table 3 presents descriptive statistics, correlations and reliabilities for all relevant variables. Analyses were tested for HMD conditions vs. laptop condition (dummy coded: HMD = 1, laptop = 0). As expected, the analyses yielded a positive effect on PRS (b = .54, p < .01) indicating that the HMD conditions were perceived as more restorative compared to the laptop condition. Testing the postulated mediation, higher PRS lead to significantly stronger increases in positive affect (indirect effect = .13, *SE* =.05, 95% *CI* [.04, .24), and significant decreases in negative affect (indirect effect = -.06, *SE* =.03, 95% *C*I [-.13,

-.01]), which confirmed the mediation hypothesis of PRS on emotional recovery. Thus, H1a, H1b and H1c were supported.

The effect of different types of nature for calming vs. stimulating. Table 4 presents descriptive statistics and reliabilities of all relevant variables. A 2 (type: HMD soft vs. HMD spectacular) x 2 (energy: stimulating vs. calming)-mixed model ANOVA revealed a significant main effect of energy $F(1,63) = 15.62$, $p < .01$, $\eta^2 = .20$, indicating that the degree of stimulation/calming changed over time (before/ after the intervention). Contrary to our expectation, the interaction effect was not significant, $F(1,63) = 2.21$, $p < .14$, $\eta^2 = .03$. Nevertheless, we further explored the pattern using paired t-tests. They showed that the calming effect was stronger than the stimulating effect in the soft nature condition, $t(32) = -4.47$, $p < 01$, while there were no significant differences between the calming and stimulating effect in the spectacular nature condition, $t(32) = -1.54$, $p = .13$. Thus, the results confirm H2a, but not H2b.

Testing the postulated mediation, for HMD spectacular nature, higher fascination led to significantly stronger increases in positive affect (indirect effect = .16, *SE* =.07, 95% *CI* [.04, .32]), and significantly stronger decreases in negative affect (indirect effect = -.06, *SE* =.03, 95% *CI* [-.13, -.01]). Thus H3a and 3b were confirmed.

Study 3

Study 3, we tested the effects of different nature VRs on a blue-collar worker (nightshift worker) sample using a within-subject design.

Methods

Ethics Statement, intervention conditions, measures, and analytic strategy were the same as in Study 1.

Subjects. 26 production employees voluntarily participated in the study. Four participants were excluded from further analyses due to sickness caused by the HMD. This final sample comprised 22 individuals (4 women; mean age 41.67 years, *SD* = 11.13, range: 21 - 61). All participants had good knowledge of the German language. Several participants had Turkish as their native language. Thus, we additionally provided Turkish versions of all questionnaires where needed. This version was established through careful forward translation. The sample of these nightshift workers was chosen because their working time is at night and they have relatively few possibilities to spend their work breaks. Thus, they might profit from the current intervention.

Procedure. The study was conducted in 2015 and ran for one week at night from 11:00 pm - 01:30 am with night workers in a common-room. Participants took part in the micro break interventions from Wednesday to Friday. Each participant participated in each intervention for three successive nights (within-subject design). A break room next to the production hall was used for the study. Three participants were able to partake in the study simultaneously. Note that the current participants do not have a typical weekend, which normally has to be observed to interpret changes before or following a weekend. Every night worker has specific nights off, following a balanced interval according to a regular schedule.

Data Analysis. To test the postulated hypotheses, we conducted correlation analyses, variance analyses, and mediation analyses with ordinary least squares regression and 10000 bootstrap samples using the MEMORE tool (Montoya & Hayes, 2017; procedures by Judd, Kenny, and McClelland, 2001). In line with studies 1 and 2, we tested all indirect effects as directed hypotheses. Consistently with previous studies (Joye & Bolderdijk, 2015), we included t1 as a covariate in all analyses of affect due to differences between conditions before the intervention.

Results

The effect of immersion. Table 5 presents descriptive statistics, correlations and reliabilities for all relevant variables. Analyses were tested for HMD conditions vs. laptop condition (within subject). As expected, the analyses yielded a positive effect on PRS (b = .70, $p < .05$), indicating that the HMD conditions were perceived as more restorative compared to the laptop condition. Testing the postulated mediation, higher PRS did not lead to an increase in positive affect (indirect effect = .25, *SE* =.20, 90% *CI* [-.01, .62]) nor to a decrease in negative affect (indirect effect = -.02, *SE* =.05, 90% *CI* [-.11, .04]). Thus, H1a was confirmed, whereas H1b and H1c were rejected.

The effect of different types of nature for calming vs. stimulating. Table 6 presents descriptive statistics and reliabilities for all relevant variables. A 2 (type: HMD soft vs. HMD spectacular) x 2 (energy: stimulating vs. calming)-within-subject ANOVA revealed no significant main effect of energy, $F(1,14) = .74$, $p = .41$, $\eta^2 = .05$, and no main effect of nature type, $F(1,14) = .04$, $p = .84$, $\eta^2 = .00$, nor an interaction, $F(1,14) = .21$, $p = .65$, $\eta^2 = .02$, which speaks against a direct effect of the spectacular or soft nature on stimulation or calming (see Table 6). Thus, H2a and H2b were not supported.

Testing the postulated mediation, for HMD spectacular nature, higher fascination led to significant stronger increases in positive affect (indirect effect = .40, *SE* =.26, 95% *CI* [-.02, .97], 90% *CI* [.03, .87]), but higher fascination did not lead to decreases in negative affect (indirect effect = -.07, *SE* =.07, 90% *CI* [-.18, .03]). Thus H3a was confirmed, whereas 3b was rejected.

Discussion

We investigated the restorative effects of virtual nature with different degrees of immersion (laptop screen vs. HMD) and different types of environments (spectacular vs. soft nature) in three different samples (academics, white-collar workers and blue-collar workers). Analyses confirmed our hypotheses that highly immersive simulations led to a better perception of the restorative quality of VR (H1a) than a low immersive simulation. For academics and white-collar workers, the highly immersive simulations indirectly increased positive affect

(H1b) and decreased negative affect (H1c). Higher restorative quality led to stronger increases in positive affect and decreases in negative affect. These results are in line with research showing the role of immersion for perceived realism and for the restorative effects of nature (de Kort & IJsselsteijn, 2006). Overall, our results support the assumption that immersion is an essential factor for the creation of restorative virtual environments.

Additionally, the current data confirmed our idea that soft and spectacular nature can alter different affective states: in two of the three studies conducted (academics and white-collar workers), the calming effect was stronger than the stimulating effect in the soft nature condition (H2a). Moreover, in the academic sample, the stimulating effect of the spectacular nature condition was marginally stronger than the calming effect (H2b). Hence, soft and spectacular VRs might have some specific beneficial impact for recovery, depending on the degree of pleasant stimulation vs. calming. Moreover, we could show that spectacular nature is perceived as more fascinating than soft nature, which indirectly promotes emotional recovery. In particular, increased fascination elicited by spectacular nature led to stronger increases in positive affect (H3a) and stronger decreases in negative affect compared to the HMD soft nature intervention (H3b). These findings are in line with Joye and Bolderdijk's (2015) thesis that awe-inspiring nature improves mood by eliciting a more intense, fascinating experience. Hence, the current research overturns the past assumption that only 'softly' fascinating environments can trigger recovery. Overall, our results suggest that spectacular, highly fascinating nature may provide unique chances for recovery, which have previously been widely neglected.

Implications and strengths of the current research

There are several advantages to the use of VRs as a means to provide restful experiences during work breaks. First, the weakness of field-based studies is the lack of control of all environmental features that might affect consequences of the independent variable. In the current project, this dilemma was resolved with the use of virtual realities, banishing—or at least reducing—confounding variables by increasing the degree of immersion in the scene. Thus, the use of VRs offers highly standardized experiments, giving new insights into field-based break interventions.

Second, by offering spaceless virtual environments, the actual break room, in the sense of a real place, appears to become less important. As in dreams, virtual realities can allow a short escape from a stressful situation during which individuals recover their individual resources anywhere, and at any time.

Third, the three different subject groups in the current research demonstrate that various professions might benefit from the use of highly immersive, virtual natural environments - probably, all individuals who have no possibility to real natural environments during their short work break. Moreover, the use of VRs as recovery interventions corresponds with the young society of ‘digital natives’ quite naturally utilizing various technological devices in different areas of their lives. A particularly interesting area might be the use of HMDs for young people, e. g. in schools. In addition, even people with impaired mobility could use HMDs to view places they could not visit in real life. Thus, HMDs might also be beneficial in retirement homes to distract elderly people from their situation.

Limitations and future research questions

There are several limitations and improvement proposals for the current research. First, in the three presented studies, we used different samples to validate the assumption that our provided micro break interventions could be beneficial for mixed subjects. The current results mainly confirm our expectations, but the white-collar workers and academics showed more recovery effects than the blue-collar workers. One reason for this fact could be the small sample size that was used investigating blue-collar workers. Thus, while the results presented seem to be valid for academics and white-collar workers, further studies are needed to better understand the effects of VRs on recovery among blue-collar workers, particularly those working at night.

Second, several aspects of the research design and measures present limitations. We used only one soft and one spectacular nature scenario. Future research is needed to generalize the current findings across a larger amount of VRs offering different nature scenes. In addition, the soft nature condition includes much water and greenery – both ambient qualities that are typically associated with recovery experiences (e.g., Pretty, Peacock, Sellens and Griffin, 2005). In addition, it contains natural sounds, like bird sounds, that are normally perceived as highly restorative (e.g., Alvarsson, Wiens, & Nilsson, 2010). In contrast, the spectacular nature condition includes more savannah and wildlife – both ambient qualities that are generally associated with more insecurity (e.g., no availability of water or food, threatening animals) that might be a barrier to recovery (Ulrich et al., 1991). Thus, besides manipulating the degree of calming vs. stimulation, other variables might have influenced the current results and should be controlled in future research.

However, even more interesting might be that the spectacular nature scenario outperformed the soft nature scenario, even though theoretically, the soft nature scenario offers much more restorative potential. This fact represents a novel insight into the investigation of restorative environments and should be further examined in subsequent studies.

Third, due to a time constraints we used single-items to assess PRS. Further studies should replicate our results with three item solutions. In addition, we used self-reported measures to investigate resource recovery. Physiological and cognitive measures could show additional effects. In this context, the use of bio- or neuro-monitoring (e.g., skin conductance level, breathing, pulse, EEG, or fMRI) should be considered.

Fourth, it is known that people prefer to control their environment (Vischer, 2007). Hence, the mere possibility of choosing between two different VRs may be enough to strengthen recovery, since it would also enhance the perceived control. In addition, a degree of freedom to choose the break time might also show beneficial effects (Vischer, 2007; Wendsche &

Lohmann-Haislah, 2016).

Fifth, it should be taken into account that the restorative effects of nature scenes may depend on individual or situational factors. For instance, the degree of vocational exhaustion might be of interest: individuals who are completely exhausted, could benefit more from calming environments, whereas individuals, who are rarely exhausted could benefit from more stimulating environments. This notion is based on the fact that humans which are not fully depleted are able to invest some energy before gaining positive effects, while fully depleted humans have no energy left (Sonnentag et al., 2008; Staats & Hartig, 2004). Therefore, spectacular nature could be beneficial for individuals who are bored by their work rather than burned out. In line with this assumption, Staats and Hartig (2004) showed different environmental preferences depending on the degree of attentional fatigue (fatigued people preferred natural over urban environments) and social context (the presence of another person increased preference only for the urban environment; see also Hartig & Staats, 2006; Staats, Kieviet & Hartig, 2003). Thus, further studies could provide different types of restorative environments (e.g., stimulating vs. calming; with vs. without people) depending on the degree of personal exhaustion.

Sixth, in the current studies, we did not induce emotional depletion before the treatment. However, participants were at their real workplaces and had worked for at least two hours before taking part in the break intervention. Thus, we measured ‘real’ depletion before the intervention and compared it with a second measurement after the intervention. Hence, instead of artificially inducing depletion (like in the laboratory), our studies predict real behaviour at real workplaces.

Seventh, the overall perceived comfort of (virtual) environments depends not only on the visual and auditory input, but also on other stimuli, such as perceived air quality or temperature (Depledge et al., 2011; Frontczak & Wargocki, 2011). Congruent stimuli foster perceived realism and thereby, positive outcomes (Alvarsson et al., 2010). Hence, future VR studies should take into account other sensory impressions besides vision and audition, such as congruent ambient smells or haptic experiences (Sona & Steidle, 2016). For instance, by adding scents to VRs, subjects could use the information of changing smells to evaluate distance from specific objects (Toet & Schaik, 2013).

Conclusion

The current research indicates that highly immersive presentations of nature can help individuals to recover during short work breaks. Moreover, nature type matters: soft and spectacular nature scenes trigger different recovery outcomes. Thereby, this research points out new perspectives for the creation of restorative VRs.

References

Alvarsson, J.J., Wiens, S., & Nilsson, M.E. (2010). Stress recovery during exposure to nature sound and environmental noise. *International Journal of Environmental Research and Public Health*, 7(3), 1036–1046. doi:10.3390/ijerph7031036

Abele-Brehm, A., & Brehm, W. (1986). Zur Konzeptualisierung und Messung von Befindlichkeit. Die Entwicklung der "Befindlichkeitsskalen" (BFS). *Diagnostica*, *32*(3), 209-228.

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology, 25*(3), 249–259. doi:10.1016/j.jenvp. 2005.07.001

Berto, R., Baroni, M.R., Zainaghi, A., & Bettella, S. (2010). An exploratory study of the effect of high and low fascination environments on attentional fatigue. *Journal of Environmental Psychology, 30*, 494–500. doi:10.1016/j.jenvp.2009.12.002

Beute, F., & de Kort, Y.A.W. (2014a). Natural resistance: Exposure to nature and self-regulation, mood, and physiology after ego-depletion. *Journal of Environmental Psychology*, *40,* 167–178. doi:10.1016/j.jenvp.2014.06.004

Beute, F., & de Kort, Y.A.W. (2014b). Salutogenic effects of the environment: Review of health protective effects of nature and daylight. *Applied Psychology: Health and Well-Being*, *6*(1), 67–95. doi:10.1111/aphw.12019

de Kort, Y.A.W., Meijnders, A.L., Sponselee, A.A.G., & IJsselsteijn, W.A. (2006). What's wrong with virtual trees? Restoring from stress in a mediated environment. *Journal of Environmental Psychology, 26,* 309–320.

Depledge, M.H., Stone, R.J., & Bird, W., J. (2011). Can natural and virtual environments be used to promote improved human health and wellbeing? *Environmental Science & Technology, 45,* 4660–4665. doi:10.1021/es103907m

Edwards, J.R., & Lambert, L.S. (2007). Methods for integrating moderation and mediation: a general analytical framework using moderated path analysis. *Psychological Methods, 12*, 1-22. doi:10.1037/1082-989X.12.1.1

Ethical Principles of Psychologists and Code of Conduct. Requested on 24/03/2017 at http://www.apa.org/ethics/code/index.aspx.

Fredrickson B.L. (2000). Cultivating positive emotions to optimize health and well-being. *Prevention & Treatment*, 3(1), Article 1. doi: 10.1037/1522-3736.3.1.31a

Frontczak, M., & Wargocki, P. (2011). Literature survey on how different factors influence human comfort in indoor environments. *Building and Environment, 46*, 922-937.

Grimshaw, M. (2014). *The Oxford Handbook of Virtuality.* Oxford: Oxford Univ. Press.

Hartig, T., Böök, A., Garvill, J., Olsson, T., & Gärling, T. (1996). Environmental influences on psychological restoration. *Scandinavian Journal of Psychology, 37*(4), 378–393. doi:10.1111/j.1467-9450.1996.tb00670.x

Hartig, T., & Staats, H. (2006). The need for psychological restoration as a determinant of environmental preferences. *Journal of Environmental Psychology*, *26*(3), 215–226. doi:10.1016/j.jenvp.2006.07.007

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health*, *35*, 207–228. doi: 10.1146/annurev-publhealth-032013-182443

Hayes, A. F. (2013). *Introduction to Mediation*, *Moderation, and Conditional Process Analysis*: A Regression-Based Approach. New York: John Wiley & Sons.

Hoffman, H.G., Chambers, G.T., Meyer, W.J., Arceneaux, L.L., Russell, W.J., Seibel, E.J., Richards, T.L., Sharar, S.R., & Patterson, D.R. (2011). Virtual reality as an adjunctive non-pharmacologic analgesic for acute burn pain during medical procedures. *Annals of Behavioral Medicine*, *41*(2), 183-91.

Joye, Y., & Bolderdijk, J.-W. (2015). An exploratory study into the effects of extraordinary nature on emotions, mood, and prosociality. *Frontiers in Psychology, 5,* 1577. doi:org/10.3389/fpsyg.2014.01577

Judd, C.M., Kenny, D.A., & McClelland, G.H. (2001). Estimating and testing mediation and moderation in within-subjects designs. *Psychological Methods*, *6*, 115-134.

Kaplan, S., & Berman, M.G. (2010). Directed attention as a common resource for executive functioning and self-regulation. *Perspectives on Psychological Science, 5*(1), 43–57. doi:10.1177/1745691609356784

Kjellgren, A., & Buhrkall, H. (2010). A comparison of the restorative effect of a natural environment with that of a simulated natural environment. *Journal of Environmental Psychology, 30*(4), 464–472. doi:10.1016/j.jenvp.2010.01.011

Kuijsters, A., Redi, J., de Ruyter, B., & Heynderickx, I. (2015). Lighting to make you feel better: Improving the mood of elderly people with affective ambiences, *PLOS ONE,* 10(7). doi:10.1371/journal.pone.0132732

Marselle, M.R. Irvine, K.N. Lorenzo-Arribas, A., & Warber S.L. (2016). Does perceived restorativeness mediate the effects of perceived biodiversity and perceived naturalness on emotional well-being following group walks in nature? *Journal of Environmental Psychology, 46,* 217–232. doi: http://dx.doi.org/10.1016/j.jenvp.2016.04.008

Marselle, M.R. Irvine, K.N., Lorenzo-Arribas, A., & Warber S.L. (2015). Moving beyond green: Exploring the relationship of environment type and indicators of perceived environmental quality on emotional well-being following group walks. *International Journal of Environmental Research and Public Health, 12* (1), 106-130. doi: http://dx.doi.org/10.3390/ijerph120100106

McNair, D.M., Lorr, M., & Droppelman, L.F. (1971). *Edits manual for the profile of mood states*. San Diego, CA: Educational and Industrial Testing Service.

Montoya, A.K., & Hayes, A.F. (2017). Two condition within-participant statistical mediation analysis: A path-analytic framework. *Psychological Methods*, *22*(1), 6-27. doi:10.1037/ met0000086.

Preacher, K.J., Zyphur, M.J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation, *Psychological Methods*, *15,* 209–233.

Pretty, J., Peacock, J., Sellens, M., Griffin, M. (2005). The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research*, *15,* 319–337.

Russell J.A., & Barrett L.F. (1999). Core affect, prototypical emotional episodes, and other things called emotion: Dissecting the elephant. *Journal of Personality and Social Psychology*, *76,* 805–819.

Russell J.A. (2003). Core affect and the psychological construction of emotion. *Psychological Review*, *110* (1), 145–172. doi:10.1037/0033-295X.110.1.145

Sandifer, P.A., Sutton-Grier, A.E., & Ward, B.P. (2015). Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. *Ecosystem Services*, *12*, 1–15. doi: org/10.1016/j.ecoser.2014.12.007

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments: Speculations on the role of presence in virtual environments. *Presence: Teleoperators and Virtual Environments, 6*(6), 603-616.

Sona, B., & Steidle, A. (2016). *Recovery through technology-provided nature experiences.* Talk at the 50th Annual Meeting of the German Psychological Society (DGPs), Leipzig, Germany.

Sonnentag, S., & Zijlstra, F.R.H. (2006). Job characteristics and off-job time activities as predictors of need for recovery, well-being, and fatigue. *Journal of Applied Psychology*, *91*, 330–350.

Sonnentag, S., Binnewies, C., & Mojza, E.J. (2008). „Did You Have A Nice Evening?" A Day-Level Study on Recovery Experiences, Sleep, and Affect. *Journal of Applied Psychology, 93* (3), 674-684. doi:10.1037/0021-9010.93.3.674

Staats, H., Kieviet, A., & Hartig, T. (2003). Where to recover from attentional fatigue: An expectancy-value analysis of environmental preference. *Journal of Environmental Psychology*, *23*(2), 147–157. doi:10.1016/S0272-4944(02)00112-3

Staats, H., & Hartig, T. (2004). Alone or with a friend: A social context for psychological restoration and environmental preferences. *Journal of Environmental Psychology, 24*(2), 199–211. doi:10.1016/j.jenvp.2003.12.005

Toet, A., & van Schaik, M.G. (2013). Visual attention for a desktop virtual environment with ambient scent. *Frontiers in Psychology*, *26*(4), 1-11. doi: 10.3389/fpsyg.2013.00883.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, *11*(3), 201–230. doi:10.1016/S0272-4944(05)80184-7

Vischer, J. C. (2007). The effects of the physical environment on job performance: towards a theoretical model of workspace stress. *Stress and Health*, *23*(3), 175–184. doi:10.1002/smi.1134

Vogels I.M. (2008). *Atmoshere metrics.* In: Westerink J.H.D.M, Ouwerkerk M, Overbeek T.J. M, Pasveer W.F, de Ruyter B., editors. Probing experience: From assessment of user emotions and behaviour to development of products. The Netherlands: Springer. pp. 25 – 41.

Watson, D., Clark, L.A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the panas scales. *Journal of Personality and Social Psychology, 54*(6), 1063-70.

Yik, M., Russell, J.A., & Steiger, J.H. (2011). A 12-point circumplex structure of core affect. *Emotion, 11*(4), 705-731. doi:10.1037/a0023980

Table 1

Study 1. The effect of immersion. Descriptives and Correlations.

		Laptop (*N*=19)		**HMD (*N*=32)**							
	Dependent Variable	M	(SD)	M	(SD)	1	2	3	4	5	6
1	PRS	3.86	(0.87)	5.09	(0.72)	**.72**					
2	Fascination	3.05	(1.27)	5.00	(1.05)	.90**	-				
3	Positive Affect t1	3.62	(0.86)	3.41	(0.98)	.01	-.02	**.91**			
4	Positive Affect t2	3.75	(0.94)	4.16	(0.87)	.45**	.42**	.53**	**.80**		
5	Negative Affect t1	1.98	(0.83)	2.41	(1.20)	.04	.09	-.38**	-.40**	**.93**	
6	Negative Affect t2	1.50	(0.51)	1.74	(0.76)	-.20	-.01	-.42**	-.40**	.77**	**.88**

Note. $^{+}$ $p < .10$, * $p < .05$, ** $p < .001$. Reliabilities are marked in bold. t1: before intervention. t2: after intervention. HMD: head mounted display.

Table 2

Study 1. The effect of soft and spectacular nature. Descriptives and Results of the ANOVA.

	Cronbach's Alpha	**Soft Nature (*N*=16)**		**Spectacular Nature (*N*=16)**	
Dependent Variable		*M*	*(SD)*	*M*	*(SD)*
t1: High arousing, positive	.75	3.60	(1.02)	3.35	(1.22)
t1: Low arousing, positive	.77	3.33	(1.06)	3.35	(1.06)
t1: High arousing, negative	.87	2.52	(1.52)	2.02	(1.05)
t1: Low arousing, negative	.84	2.52	(1.37)	2.58	(1.28)
t2: High arousing, positive	.66	3.77	(0.86)	4.38	(1.08)
t2: Low arousing, positive	.77	4.31	(1.00)	4.19	(0.93)
t2: High arousing, negative	.87	1.73	(0.94)	1.79	(0.71)
t2: Low arousing, negative	.84	1.90	(1.13)	1.54	(0.50)
t1: Positive affect		3.60	(1.02)	3.35	(1.22)
t1: Negative affect		2.52	(1.39)	2.30	(1.01)
t2: Positive affect		3.77	(0.86)	4.38	(1.08)
t2: Negative affect		1.81	(0.96)	1.67	(0.51)
Fascination		4.63	(1.02)	5.38	(0.96)
Calming effect		1.77	(1.86)	1.06	(1.31)
Stimulating effect		0.79	(1.23)	2.06	(1.93)

Note. t1: before intervention. t2: after intervention.

Table 3

Study 2. The effect of immersion. Descriptives and Correlations.

		Laptop (*n* = 34)		HMD (*n* = 65)							
	Dependent Variable	M	(SD)	M	(SD)	1	2	3	4	5	6
1	PRS	4.38	(.95)	4.88	(.73)	**.66**					
2	Fascination	3.82	(1.42)	4.57	(1.21)	.83**	-				
3	Positive Affect t1	4.14	0.89)	3.87	(0.81)	.05	-.04	**.80**			
4	Positive Affect t2	4.31	(1.04)	4.27	(0.89)	.27**	.19	.83**	**.82**		
5	Negative Affect t1	1.77	(0.62)	1.75	(0.66)	-.10	-.04	-.65**	-.55**	**.66**	
6	Negative Affect t2	1.60	(0.62)	1.51	(0.58)	-.24*	-.16	-.53**	-.60**	.79**	**.81**

Note. $^{+}$ $p < .10$, * $p < .05$, ** $p < .001$. Reliabilities are marked in bold. t1: before intervention. t2: after intervention.
HMD: head mounted display.

Table 4

Study 2. The effect of soft and spectacular nature. Descriptives and Results of the Analyses.

	Cronbach's Alpha	Soft Nature (*n* = 33)		Spectacular Nature (*n* = 32)	
Dependent Variable		M	(SD)	M	(SD)
t1: High arousing, positive	.67	4.22	0.88)	3.94	(0.83)
t1: Low arousing, positive	.77	3.72	0.85)	3.60	(1.09)
t1: High arousing, negative	.62	1.80	0.77)	1.74	(0.67)
t1: Low arousing, negative	.73	1.74	0.87)	1.74	(0.65)
t2: High arousing, positive	.75	4.30	0.94)	4.14	(0.94)
t2: Low arousing, positive	.77	4.37	0.97)	4.27	(1.03)
t2: High arousing, negative	.62	1.47	(0.66)	1.55	(0.69)
t2: Low arousing, negative	.73	1.60	0.77)	1.43	(0.54)
t1: Positive affect		3.97	(0.81)	3.77	(0.81)
t1: Negative affect		1.77	(0.75)	1.74	(0.57)
t2: Positive affect		4.34	(0.93)	4.20	(0.86)
t2: Negative affect		1.54	(0.68)	1.49	(0.48)
Fascination		4.18	(1.26)	4.97	(1.03)
Calming effect		0.98	0.89)	0.85	(1.19)
Stimulating effect		0.22	0.86)	0.51	(1.14)

Note. t1: before intervention. t2: after intervention.

Table 5

Study 3. The effect of immersion. Descriptives and Correlations.

	Laptop (n = 20-21)		HMD (n = 19-22)							
Dependent Variable	M	*(SD)*	M	*(SD)*	1	2	3	4	5	6
PRS	3.88	(1.39)	4.54	(1.28)	**.82**					
Fascination	3.05	(1.86)	4.24	(1.58)	.97**	-				
Positive Affect t1	3.92	(1.29)	3.75	(1.18)	-.04	-.03	**.96**			
Positive Affect t2	4.29	(1.38)	4.55	(1.18)	.43	.43	.69**	**.96**		
Negative Affect t1	1.33	(0.39)	1.48	(0.55)	-.30	-.33	-.53*	-.59**	**.89**	
Negative Affect t2	1.33	(0.39)	1.35	(0.47)	-.42	-.45	-.53*	-.67**	.64**	**.88**

Note. $^{+}$ $p < .10$, * $p < .05$, ** $p < .001$. Reliabilities are marked in bold. t1: before intervention. t2: after intervention. HMD: head mounted display.

Table 6

Study 3. The effect of soft and spectacular nature.

Descriptives and Results of the Analyses.

	Cronbach's Alpha	Soft nature (*n*= 15)		Spectacular Nature (*n* = 16)	
		M	*(SD)*	*M*	*(SD)*
t1: High arousing, positive	.95	4.04	(1.11)	4.24	(1.12)
t1: Low arousing, positive	.95	3.73	(1.45)	3.71	(1.63)
t1: High arousing, negative	.80	1.29	(0.50)	1.29	(.58)
t1: Low arousing, negative	.85	1.58	(0.67)	1.56	(.65)
t2: High arousing, positive	.94	4.60	(1.18)	4.60	(1.35)
t2: Low arousing, positive	.91	4.27	(1.51)	4.33	(1.74)
t2: High arousing, negative	.58	1.13	(0.30)	1.22	(0.41)
t2: Low arousing, negative	.88	1.51	(0.75)	1.44	(0.69)
t1: Positive affect		3.79	(1.23)	3.96	(1.27)
t1: Negative affect		1.41	(0.51)	1.39	(0.46)
t2: Positive affect		4.56	(1.18)	4.61	(1.39)
t2: Negative affect		1.32	(0.47)	1.28	(.45)
Calming effect		0.69	(1.35)	0.69	(1.04)
Stimulating effect		0.62	(0.97)	0.47	(1.16)

Note. t1: before intervention. t2: after intervention

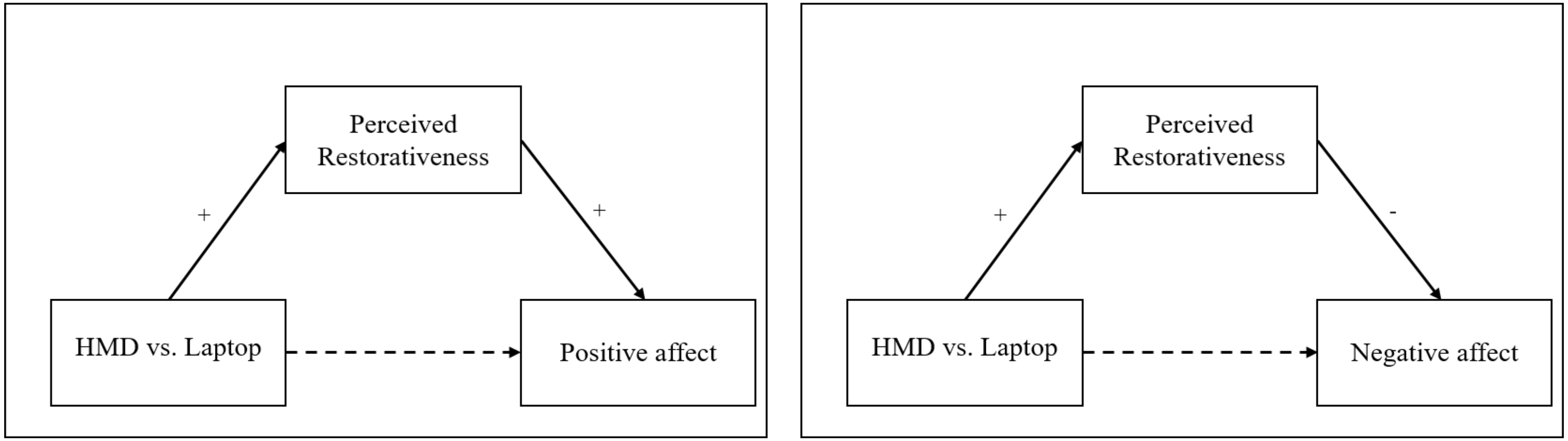


Fig. 1. Hypothesis 1. Compared to a laptop screen presentation (= 0), the presentation of a nature scene presented via HMD (= 1) should increase the perceived restorativeness of the environment (H1a), which indirectly should increase positive affect (rigth; H1b) and decrease negative affect (left; H1c).

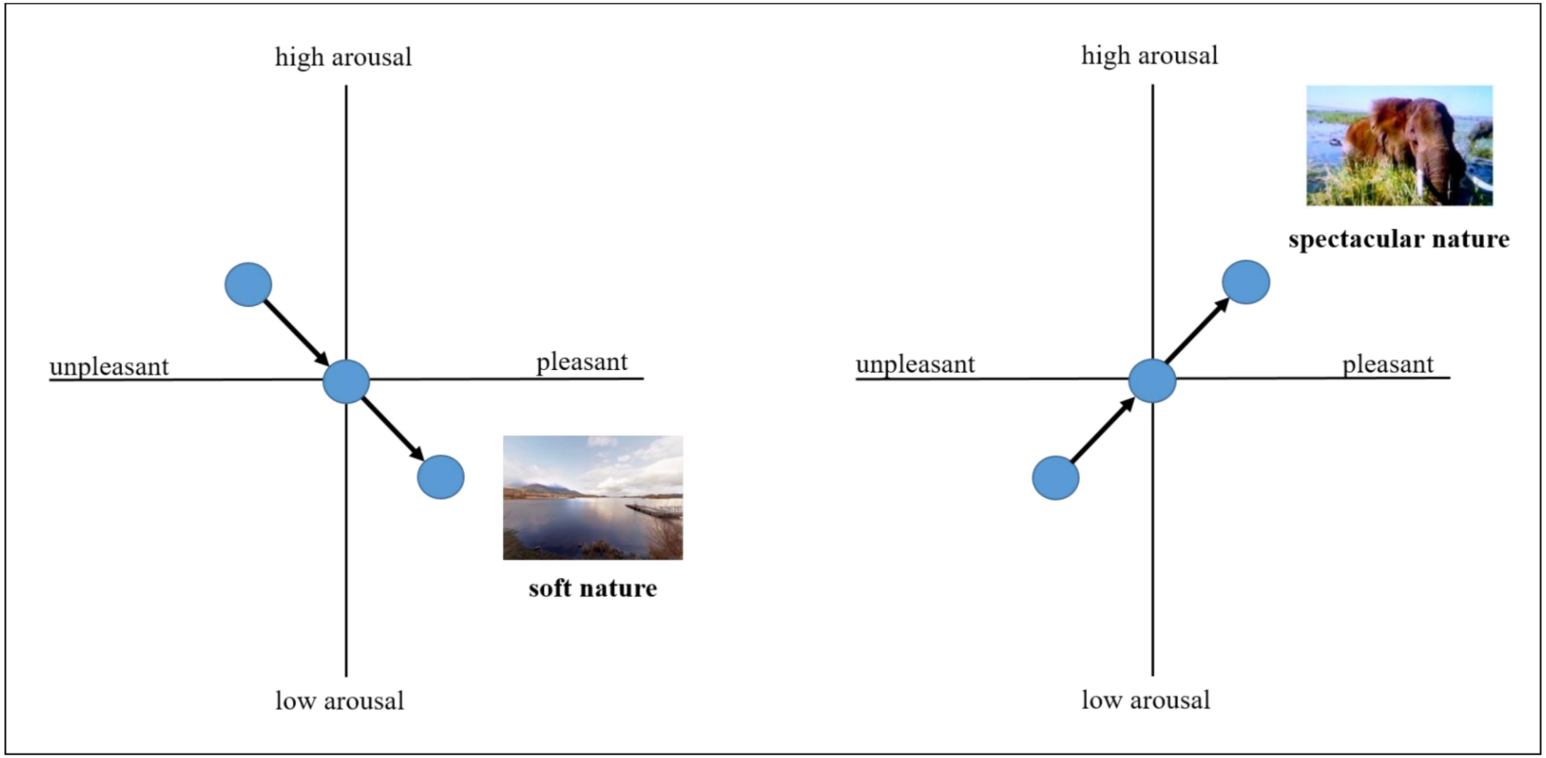


Fig. 2. Hypothesis 2. Soft nature should evoke calming rather than stimulation (left; H2a), whereas spectacular nature should evoke stimulation rather than calming (right; H2b).

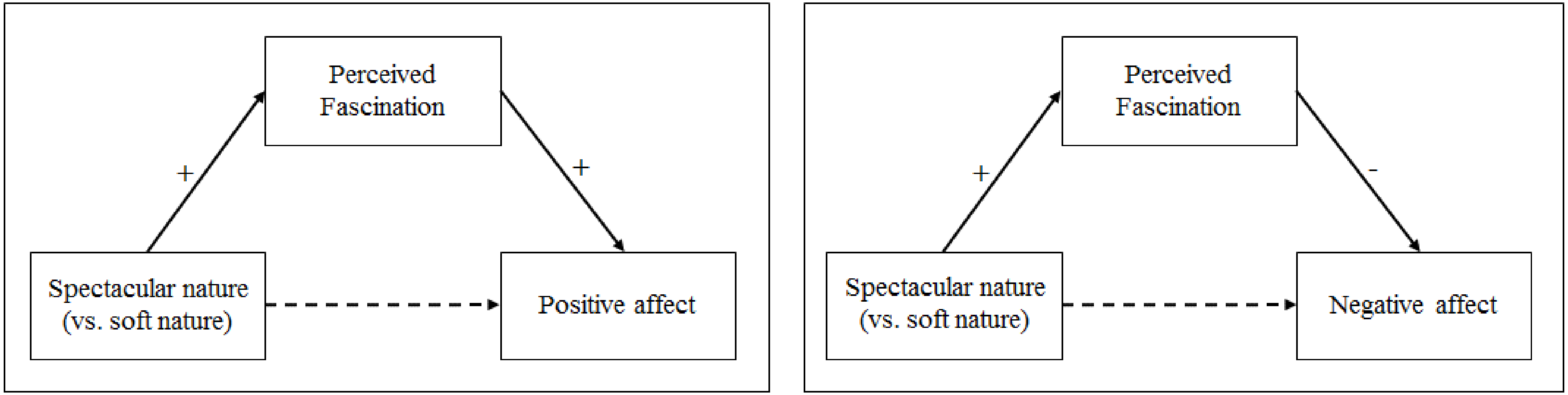


Fig. 3. Hypothesis 3. Spectacular nature is perceived as more fascinating than soft nature, which indirectly should increase positive affect (leftt; H3a) and decrease negative affect (right; H3b).

Chapter 5: General Discussion

During work, people need breaks to refill depleted personal resources. In particular, restorative environments have a positive impact on individuals' perception, cognition, and affect. The aim of the present doctoral thesis was to uncover restorative environments and their ambient qualities.

The thesis answers the following questions: Which environments and which ambient qualities support restoration? Do people choose different environments for recovery depending on the type of depletion (emotional vs. cognitive)? Can we foster recovery through congruent, sensory impressions in simulated worlds? How important is the degree of immersion in a simulated world and the type of environment (soft vs. spectacular nature) for recovery? Qualitative and quantitative research projects in lab and field were conducted to gain an impression of what the detailed answers to these questions might be. A brief overview of the research results follows this section.

5.1 Summary of results

The first research question addressed the identification of restorative environments and their specific ambient qualities. The question was answered with an explorative study which identified five outdoor ('park/garden', 'edge of the forest', 'nature', 'fields/meadows' and 'sea/beach/lake/water') and four indoor environments ('home', 'living room', 'my room' and 'café'; see Chapter 2) with high restorative potential. Moreover, the study identified two key elements for fostering PRP in outdoor environments (bright/sunny lighting and green color) and four key elements in indoor environments (bright/sunny lighting, 21–25 °C, white color, and brown color). The study showed that humans choose their environment depending on the type of depletion: Outdoor environments were preferred after cognitive depletion, and indoor environments after emotional depletion.

The second research question investigated the benefits of congruent sensory impressions on recovery (see Chapter 3). Results showed that congruent audiovisual and olfactory impressions were perceived as more pleasant and more restorative than a standard break room, which in turn facilitated the recovery of personal resources. This research contributes to theory testing uncovering the psychological pathway from specific environmental stimuli through environmental perceptions to recovery.

The third research question concerned the impact of the degree of immersion in a simulated world and the type of the environment for recovery (see Chapter 4). As expected, a higher degree of immersion promoted greater recovery effects. This finding indicates that the same amount of sensory impressions (here: auditory and visual) has different recovery effects depending on the degree of immersion. In addition, recovery was facilitated by both calming (soft nature) and stimulating environments (spectacular nature). In line with the second research project, the present studies again showed the psychological pathway from specific environmental stimuli through environmental perceptions to recovery. The generalizability of the present research was illustrated by testing academics, white-collar and blue-collar workers.

5.2 Strengths of the current research

In terms of theory building, the current thesis outlines the theoretical framework of RET by identifying concrete outdoor and indoor environments and their ambient qualities with high recovery potential. Thus, the assumption of RET that humans prefer nature (Kaplan, 1992; Ulrich, 1983) was complemented by the fact that distinct indoor environments (in particular, home environments) are also appropriate places for recovery (see also Richter, 2008; Vischer, 2007). In addition, the present research provides detailed information about the environments mentioned and their ambient qualities. Thereby, it indicates that not every natural and not every indoor environment is perceived as restorative, but rather that specific ambient qualities define an environment as restorative. For instance, the key element of ‘bright light’ fostered PRP in indoor as well as outdoor environments and might therefore be highly important for recovery. Hence, the detailed descriptions of environments and their ambient qualities support more precise theory building.

In terms of theory testing, the thesis confirms the benefits of congruent sensory impressions for indoor and outdoor environments. In particular, the thesis outlines the benefits of congruent ambient scents and audiovisual impressions for various recovery outcomes. The perceived pleasantness of distinct ambient qualities enhanced PRP (see also Alvarsson et al., 2010; Bensafi et al., 2002; Doucé et al., 2014; Herz, 2004). In line with ART (Kaplan & Kaplan, 2011), the current research pointed out that esthetically pleasing environmental stimuli (here: pleasant ambient scents) strengthen recovery perceptions (e.g., fascination; Kaplan, 1995, 2001) to foster recovery. These results are in line with previous research showing the positive effects of congruent visual and auditory stimuli on recovery perceptions (Annerstedt et al., 2013; Alvarsson et al., 2010).

In addition, this research pointed out that the degree of immersion in a simulated world has a significant influence on recovery. In line with Grimshaw (2014), the current research indicates that the higher the perceived immersion (here: head movement/360° perspective) in the presented simulation, the greater the PRP, which in turn strengthens recovery of depleted resources. The current thesis further pointed out that the same amount of sensory impressions (auditory and visual) has different recovery effects depending on the degree of immersion. Thus, in simulating restorative environments, the degree of immersion should be considered besides the amount of congruent sensory impressions.

Moreover, the thesis demonstrates that humans require different environments depending on the type of depletion (cognitive vs. emotional). After cognitive depletion they prefer natural outdoor environments, whereas after emotional depletion they prefer built indoor environments to recover. This finding corresponds to ART (Kaplan & Kaplan, 1982), postulating that humans are drawn to nature to recover from attentional fatigue. However, the results remain in contrast to SRT (Ulrich, 1983), postulating that humans are likewise drawn to nature to recover from emotional depletion. Thus, the current thesis outlines a novel insight investigating restorative environments: If individuals could choose, they would prefer indoor environments for emotional recovery and outdoor environments for cognitive recovery. These results also reflect former research (Gulwadi, 2006) and indicate the necessity to differentiate which environments are suitable for what kind of recovery.

In addition, RET has assumed to date that only calming environments are appropriate places for recovery (Kaplan, 1995; Kaplan and Berman, 2010). In contrast, the current thesis has showed that both calming and stimulating environments might be beneficial (see also Joye & Bolderdijk, 2014). This novel insight is again an important contribution for theory building, since it might shift the focus of attention towards the consideration of different personal needs.

Overall, the thesis provides support for the proposed psychological pathways from specific environments (type of environment; ambient qualities; simulated sensory input) to the recovery of personal resources (e.g., emotional resources) through processes of perception (pleasantness; PRP; see Fig. 2; adapted from Kaplan, 1995, 2001; Marselle et al., 2016). The investigation of all these factors within one research model has yielded new insights into theory building and theory testing of restorative environments. Thus, the current thesis represents a significant contribution to the development of the research in this area.

Furthermore, the thesis provides a transfer from the laboratory setting to the field, investigating participants directly at the workplace and thereby ensuring a strong application orientation. The external validity of the research was confirmed by testing academics and blue-collar and white-collar workers.

5.3 Limitations and future questions

The following section will point out limitations of the current thesis in proposing recommendations for future research. First, according to the habitability pyramid (Vischer, 2007), perceived control over an environment enhances psychological comfort and might therefore foster recovery and well-being. In the research presented, participants were randomly assigned to the experimental conditions. Thus, a free choice of environment was not possible. Hence, future studies might investigate the impact of individual selection from several environments (e.g., outdoor vs. indoor environment; soft vs. spectacular nature) on recovery.

Second, the current thesis concentrated on the manipulation of simulated vision, audition, and ambient scent. Since the results for ambient scents were rather small, future studies are needed to confirm the presented findings. In addition, the data captured from the explorative study provides much more information than was used in the present thesis. Thus, future research could use the results of the explorative study to investigate other ambient impressions, e.g., the effects of different temperatures, lighting conditions, or persons within an environment on PRP and various recovery outcomes. Moreover, interactions between different ambient qualities should also be further explored.

Third, the current thesis concentrated on subjective recovery outcomes, such as mood, self-control, and arousal, so that objective measurements, e.g., physiological or cognitive data, are missing. However, former studies elucidated the physiological effects of natural environments on recovery (Beute, & de Kort, 2014; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Ulrich et al., 1991). In the current thesis, such data would have given a deeper understanding of the recovery process and should be taken into account in future research. Moreover, an adequate measurement of cognitive recovery would have been useful, for instance, to measure directed attention fatigue.

Fourth, implicit measurements of recovery perceptions should be considered in future research, since they cannot be manipulated by participants as easily as explicit measurements (Hofmann, Gawronski, Gschwendner, Schmitt, 2005). Individuals might not admit all recovery activities (e.g., watching TV), because it might be a less desirable behavior. Thus, in explicit terms, they might cover up their ‘real’ place preferences. Combining explicit (e.g., questionnaires) and implicit measures (e.g., implicit association test; Greenwald, Nosek & Banaji, 2003), might therefore obtain a more precise picture of what environments are restorative, independent from answers of social desirability.

Fifth, future research, including measurement of chemosensory signals, could provide novel insights into emotions as an indicator of recovery. For instance, research showed that a change in axillary perspiration occurs depending on the perceived emotions (Mutic, Rodriguez-Raecke & Freiherr, 2016). Thus, future studies might also investigate changes in axillary perspiration to determine perceived emotions during recovery interventions.

Sixth, the current thesis does not provide information about the sequence and length of time spent in different ambient spaces (e.g., time spent looking at a tree). This gap of information can be closed in future studies through the use of eye tracking data. Eye tracking might give additional understanding into human behaviour in environments by providing objective data for eye movements (fixations and saccades) and the time spent on different areas (areas of interest, AOI; Duchowski, 2003). Head mounted displays also provide the option of indicating heatmaps, visualizing how long different parts of a presented virtual world have been regarded, and scanpaths, visualizing every fixation point (Pfeiffer, 2012). The subjective results of the current thesis could thus be validated and extended.

5.4 Practical Implications

The following practical implications arise from this doctoral thesis. The thesis outlines environments with high restorative potential and their ambient qualities. It therefore enables suitable (virtual) break areas to be designed for different individual needs. According to the results, it is recommended to offer a simulated natural environment (e.g., a park or garden) for recovery from cognitive depletion, whereas it is recommended to offer an indoor environment (e.g., private home-style) for recovery from emotional depletion.

To recover, humans generally prefer to be alone or with a few individuals. The need for social contacts thus seems to be less pronounced when humans feel cognitively or emotionally depleted. As a result, it is suggested to offer places of retreat, where employees could be alone. Moreover, the current research emphasizes the relevance of ‘bright light’ that should be considered by the design of restorative environments.

In the sense of space efficiency, it would be possible to use the same break environment by simply changing the view in an artificial window or a head-mounted display according to individual needs. Furthermore, the present research suggests increasing the recovery potential of windowless break rooms through the use of artificial windows or VRs, e.g., showing calming or stimulating natural environments. In addition, congruent acoustics and scents might be beneficial for recovery. In particular, the presentation of an artificial window view or VR of nature combined with the sounds (e.g., birdsong) and scents of nature (e.g., smell of grass) might increase recovery outcomes.

Furthermore, it is proposed to use VRs in companies to present natural environments as short breaks (about 4 min.). The interventions with VRs should be performed in a separate room or area to avoid disruption to other employees and to increase privacy - a small private area with a swivel chair would be sufficient. Employees might decide on their own what type of natural environment (stimulating vs. calming) they would like to use. Moreover, it would be beneficial if they could decide independently at what time they would like to take their break to increase perceived control (Vischer, 2007). In addition, the use of effective short breaks (4 min.) represents important information for the determination of break times and corresponds to former research (Jahncke et al., 2011; Berto, 2005). Hence, as a consequence, this thesis recommends to offer short breaks (in addition to a regular lunch break) during working hours to enhance productivity and well-being.

Besides designing break areas in companies, this research gives valuable recommendations for the design of other environments as well. Theoretically, every environment where humans stay for longer periods of time may benefit from the current research, e.g., home environments, schools, universities, cafés, restaurants, airports, or hospitals.

For instance, the use of virtual environments for recovery might be particularly interesting for public transport. In the future, aircraft or trains may not provide real window views due to higher travel speeds. Thus, the use of artificial windows might help to reduce motion sickness, simulating real window views or restorative environments. Moreover, head mounted displays allow even more flexibility since individuals can use their personal devices and thereby immerse themselves in any environment, at any time.

References

Alvarsson, J.J., Wiens, S., & Nilsson, M.E. (2010). Stress recovery during exposure to nature sound and environmental noise. *International Journal of Environmental Research and Public Health, 7*(3), 1036–1046. doi:10.3390/ijerph7031036

Bakker, A.B., & Demerouti, E. (2007). The Job Demands-Resources model: State of the art. Journal of Managerial Psychology, 22, 309-328

Beute, F., & de Kort, Y. A. W. (2014). Natural resistance: Exposure to nature and self-regulation, mood, and physiology after ego-depletion. *Journal of Environmental Psychology, 40*, 167–178. doi:10.1016/j.jenvp.2014.06.004

Demerouti, E., Bakker, A. B., Nachreiner, F. & Schaufeli, W. B. (2001a). The job demands-resources model of burnout. *Journal of Applied Psychology, 86*, 499-512.

Depledge, M. H., Stone, R.J., & Bird, W., J. (2011). Can Natural and Virtual Environments Be Used To Promote Improved Human Health and Wellbeing? *Environmental Science & Technology, 45*, 4660–4665. doi: 10.1021/es103907m

Duchowski, A. T. (2003). *Eye Tracking Methodology: Theory and Practice*. London: Springer-Verlag.

Edwards, J. R., Cable, D. M., Williamson, I. O., Schurer Lambert, L., & Shipp, A. J. (2006). The Phenomenology of Fit: Linking the Person and Environment to the Subjective Experience of Person–Environment Fit. *Journal of Applied Psychology, 91*(4), 802–827. doi: 0.1037/0021-9010.91.4.802

Friedman, B., Freier, N. G., Kahn Jr., P. H., Lin, P., & Sodeman, R. (2008). Office window of the future?—Field-based analyses of a new use of a large display. *International Journal of Human-Computer Studies, 66*(6), 452–465. doi:10.1016/j.ijhcs.2007.12.005

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the implicit association test: I. An improved scoring algorithm. *Journal of Personality and*

Social Psychology, *85*(2), 197–216. doi:10.1037/0022-3514.85.2.197

Grimshaw, M. (2014). *The Oxford Handbook of Virtuality.* Oxford: Oxford Univ. Press.

Hofmann, W., Gawronski, B., Gschwendner, T., Le, H., & Schmitt, M. (2005). A meta-analysis on the correlation between the implicit association test and explicit self-report measures. *Personality and Social Psychology Bulletin*, *31*, 1369–1385.

Hug, S.-M., Hartig, T., Hansmann, R., Seeland, K., & Hornung, R. (2009). Restorative qualities of indoor and outdoor exercise settings as predictors of exercise frequency. *Health & Place, 15*(4), 971-980. doi:10.1016/j.healthplace.2009.03.002

Huisman, E. R .C. M., Morales, E., van Hoof, J., & Kort, H. S. M. (2012). Healing environment: A review of the impact of physical environmental factors on users. *Building and Environment*, 58, 70–80. doi: http://dx.doi.org/10.1016/ j.buildenv.2012.06.016

Inzlicht, M., Schmeichel, B.J., & Macrae, C.N. (2014). Why self-control seems (but may not be) limited. *Trends in Cognitive Sciences, 18*(3), 127-133.

Kahn, P. H., Severson, R., & Ruckert, J. (2009). The Human Relation with Nature and Technological Nature. *Current Directions in Psychological Science*, *18*(1), 37–42.

Kaplan, S., & Berman, M.G. (2010). Directed attention as a common resource for executive functioning and self-regulation. *Perspectives on Psychological Science, 5*, 43–57.

Mujtaba, B. G., Cavico, F. J. (2013). Corporate Wellness Programs: Implementation Challenges in the Modern American Workplace. *International Journal of Health Policy and Management*, *1*(3), 193–199.

Paddle, E. & Gilliland, J. (2016). Orange is the new green: Exploring the restorative capacity of seasonal foliage in schoolyard trees. *International Journal of Environmental Research and Public Health*, *13*, 497-515.

Pfeiffer, T. (2012). Measuring and visualizing attention in space with 3d attention volumes. In *Proceedings of the 2012 Symposium on Eye Tracking Research & Applications* (ETRA'12), 29–36.

Maas, J., Verheij, R. A., Groenewegen, P. P., de Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: How strong is the relation? *Journal of Epidemiology and Community Health, 60*, 587-592. doi:10.1136/jech.2005.043125

Mattila, A. S., & Wirtz, J. (2001). Congruency of scent and music as a driver of in-store evaluations and behavior. *Journal of Retailing*, 77(2), 273 – 289.

Mutic, S., Rodriguez-Raecke, R., & Freiherr, J. (2016) Functional neural processing of emotional chemosignals communicating aggression in humans. *Chemical Senses, 41*(9), E190-E191.

Sona, B., & Steidle, A. (2016). Resilienz stärken: Die Gestaltung von Erholungswelten in Pausenräumen. *Technische Sicherheit, 36*(3), 28-32.

Spangenberg, E. R., Grohmann, B., & Sprott, D. E. (2005). It's beginning to smell (and sound) a lot like Christmas: The interactive effects of ambient scent and music in a retail setting. *Journal of Business Research, 58*(11), 1583 – 1589.

Steidle, A., de Boer, J., Werth. L.,& Sedlbauer, K. (2014). Stressor oder Ressource? Die Bedeutung der bauphysikalischen Bedingungen für den Menschen am Beispiel der Lichtumgebung, *Bauphysik, 37*(5), 263-267. doi:10.1002/bapi.201510035

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman & J. F. Wohlwill (Eds.), *Behavior and the Natural Environment* (pp. 85–125). Plenum Press, New York.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*(3), 201–230. doi:10.1016/S0272-4944(05)80184-7

Vischer, J. C. (2007). The effects of the physical environment on job performance: towards a theoretical model of workspace stress. *Stress and Health, 23*(3), 175–184. doi:10.1002/smi.1134

Weng, P. Y., Chiang, Y. C. (2014). Psychological Restoration through Indoor and Outdoor Leisure Activities. *Journal of Leisure Research, 46* (2), 203–217.

White, K. E. (2013). *The Role of Nature in Physiological Recovery from Stress: A Critical Examination of Restorative Environments Theory*. Dissertation.

List of publications

Publications

Sona, B. & Steidle, A. (2016). Resilienz stärken: Die Gestaltung von Erholungswelten in Pausenräumen. *Technische Sicherheit*, *36*(3), 28-32.

Manuscripts submitted (peer-reviewed journals)

Sona, B. (2017). *Guides to recovery: Exploring ambient qualities' contribution to the perceived restorative potential of environments.*

Sona, B., Steidle, A., & Dietl, E. (2017). *Recovery in Sensory-Enriched Break Environments: Integrating Vision, Sound and Scent into Simulated Indoor and Outdoor Environments.*

Sona, B. & Steidle, A. (2017). *Powered by Virtual Realities: The Impact of Immersion in Soft and Spectacular Nature on Emotional Recovery*.

Congress contributions

Sona, B. & Steidle, A. (Mai, 2017). *Fostering resource recovery through virtual realities*. Talk to be held at the European Association of Work and Organizational Psychology (EAWOP), Dublin, Ireland.

Sona, B. & Steidle, A. (2016). *Recovery through technology-provided nature experiences.* Talk at the 50th Annual Meeting of the German Psychological Society (DGPs), Leipzig, Germany.

Sona, B. (2015). *Der Einfluss künstlicher Fenster auf das Erholungspotential in Räumen.* Invited talk at Praxisforum biologische Lichtwirkungen (BioWi), Weimar.

Sona, B., Steidle, A., & Dietl, E. (2015). *Creating restorative break rooms: Effects on* *emotional and self-control resources.* Oral presentation at the 11th Biennial Conference on Environmental Psychology, Groningen, the Netherlands.

Sona, B. (2014). *Simulated restorative environments: Creating a pleasant environment via an artificial window and a congruent* ambient scent. Oral presentation at the Doctoral Consortium of the International Conference on the Effects of Light on Wellbeing, Eindhoven, the Netherlands.

Steidle, A., Sona, B**.,** Gonzalez Morales, G., Hoppe, A., Michel, A., O'Shea, D. (2014). *Die Ressource „Natur": Simuliertes Naturerleben als Erholungsstrategie in Arbeitspausen.* Oral presentation at the 49th Congress of the German Psychological Society (DGPs), Bochum.

Sona, B.**,** Steidle, A., Werth, L. (2014). *Der Einfluss physikalischer Umgebungsfaktoren auf das Erholungspotential in Räumen.* Poster at the 49th Congress of the German Psychological Society (DGPs), Bochum.

Further presentations

Sona, B. (2017). *Pausengestaltung 5.0.* Invited talk at Munich Offices, Munich.

Sona, B. (2016). *Multimodale Sensorische Gestaltung von Erholungswelten*. Invited talk at the Fraunhofer IVV, Freising.

Sona, B. (2015). *Der Einfluss physikalischer Umgebungsfaktoren auf das Erholungspotential in Pausenräumen*. Invited talk at Vortragsreihe "Bauphysik in der Forschung", TUM, München.

Sona, B. (2014). *Der Einfluss physikalischer Umgebungsfaktoren auf das Erholungspotential in Arbeits- und Pausenräumen.* Oral presentation at the PhD Candidates Workshop, Industrial and organizational Psychology Group of the DGPS, Freiburg.

Steidle, A., González-Morales, Hoppe, A., G. M., Michel, A., O'Shea, D. & Sona, B. (2013). *Savoring nature and relaxation: Day-level respites from work and their impact on well-being and performance.* Paper presented at the EAWOP small group meeting "Resource-oriented interventions at work: Designing and evaluating interventions to promote well-being and performance", Heidelberg.