The effects of auditive and visual settings on perceived restoration likelihood

Helena Jahncke[1,2], Karolina Eriksson[3], Sanna Naula[3]

[1]Centre for Musculoskeletal Research, Department of Occupational and Public Health Sciences, Faculty of Health and Occupational Studies, [2]Environmental Psychology, Department of Building, Energy and Environmental Engineering, Faculty of Engineering and Sustainable Development, University of Gävle, Gävle, [3]Department of Psychology, Uppsala University, Uppsala, Sweden

Abstract

Research has so far paid little attention to how environmental sounds might affect restorative processes. The aim of the present study was to investigate the effects of auditive and visual stimuli on perceived restoration likelihood and attitudes towards varying environmental resting conditions. Assuming a condition of cognitive fatigue, all participants (*N* = 40) were presented with images of an open plan office and urban nature, each under four sound conditions (nature sound, quiet, broadband noise, office noise). After the presentation of each setting/sound combination, the participants assessed it according to restorative qualities, restoration likelihood and attitude. The results mainly showed predicted effects of the sound manipulations on the perceived restorative qualities of the settings. Further, significant interactions between auditive and visual stimuli were found for all measures. Both nature sounds and quiet more positively influenced evaluations of the nature setting compared to the office setting. When office noise was present, both settings received poor evaluations. The results agree with expectations that nature sounds and quiet areas support restoration, while office noise and broadband noise (e.g. ventilation, traffic noise) do not. The findings illustrate the significance of environmental sound for restorative experience.

Keywords: Open plan office, sound, restoration, urban nature

Introduction

Cities are growing and with them the ambient noise.[1] Daily, citizens are exposed to sounds from traffic, trains, people, construction work, overflights and many other sources. In addition, it is common to be exposed to a variety of noise sources at work, particularly for modern industrial-and open-plan office workers. Different noise sources, such as road traffic, overflights and co-workers in offices have adverse effects on people, from annoyance to increased fatigue and impaired performance to severe health problems.[1-4] Once common sounds, such as bird twitter and rippling of water, are moreover often masked by noise sources in large cities,[5] if they are present at all. If nature sounds present in cities were more audible, they could have positive effects on inhabitants. Alvarsson *et al*.[6] have, for example, shown that nature sounds promote faster recovery from stress, compared with both traffic noise and ventilation noise. Further, results have indicated that the combination of natural auditory and visual stimuli (i.e. people having nature close to their residential area) can lead to less irritation with the surrounding traffic noise, compared to people without close access to nature.[7] Furthermore, watching a nature movie with sound during a break at work, compared with both quiet and continued office noise exposure, has been more beneficial for reducing self-reported fatigue and improving performance.[3,8]

Research on restorative environments has produced a large and growing literature, with numerous studies indicating that natural environments provide a more efficient way for people to recover from stress and mental fatigue than other outdoor urban settings.[9] In these studies, however, the focus has mainly been on the visual features of the environment that promote restoration, and not with natural versus urban sounds. Yet, previous research suggests that ambient sounds do affect environmental preferences.[10,11] Given the associations found between environmental preferences and aspects of restorative experience,[12,13] we expect that sounds will also affect assessments of restorative quality, with assessments grounded in one of the main theories on restorative environments, attention restoration theory (ART).[14]

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According to ART, there are certain components of person-environment transactions that promote restoration. ART mentions several components, though recent research has pointed out two components (i.e. *being away* and *fascination*) as more fundamentally important.[15,16] First, when the environment offers a person a sense of *being away* from duties and problems, the inhibitory mechanism that enables willful, directed attention gets the possibility to rest. Second, when features in the environment are *fascinating,* this entails effortless attention, which further sustains rest of the mechanism for directed and controlled attention. These two components might be applied to sounds. We assume that some environmental sounds can increase the feeling of *being away* in another environment (e.g. sounds from a forest) and increase *fascination*, as through variations and contents (e.g. twitter of birds, rippling water). A sound may also restrain or promote the fascination depending on how it is perceived. If a water sound is perceived either as "natural" (e.g. waterfall) or not (e.g. traffic sound) appears to change the direction in how tranquil it is taken to be,[17] which in turn may lead to feelings of wanting to stay in or get away from the environment.

As another source of hypotheses regarding restorative quality in environments, research on environmental determinants of tranquility has also indicated that the interaction of a setting's visual and acoustic characteristics can significantly influence the evaluation of that setting.[10] A study, which used both uni- and bi-modally presented stimuli to investigate the importance of auditory-visual interaction on the perception of tranquility showed that the scenes, which generated a high rating of bi-modal tranquility tended to be rated as more tranquil than the average of their uni-modal components, and vice versa for the less tranquil scenes.[18] The authors suggested that the combined percept resulting from a tranquil scene is enhanced by the more tranquil of the two constituent sensory inputs. Thus, there are instances in which sounds modulate the rating of the visual stimuli, showing up as an interaction between visual and auditory input. It is also reasonable from a conceptual perspective to assume that combined visual-auditory stimuli will affect people to different degrees than the visual stimuli alone. Conceivable, congruent visual and auditory stimuli reinforce one another, producing a more accurate representation of the environment and boosting evaluations, particularly when each mode is assessed as having some degree of restorative quality to begin with.

In the present study, we conjectured that environments that are rated as having moderate to high visual restorative qualities are the ones that may also have a higher potential to be influenced by auditory stimuli, at least for people with a need for restoration. As vision is a more dominant sensory channel than hearing for most people, we wanted to probe whether evaluations of settings with a low level of visual restorative qualities will be relatively robust against the influence of auditory stimuli, even if the auditory stimuli are themselves relatively restorative. Specifically, it may not help to add nature sounds if there is only weak support for restoration seen in the visual stimulus. The alternative hypothesis would be that the restorative qualities of the auditory stimuli do not depend on the restorative level of the visual stimuli. To make a choice between these alternatives we included auditive stimuli previously judged to differ in restorative qualities, in combination with two settings presented with visual images, assumed on the basis of much previous work to differ in restorative quality.[19] The hypotheses were:

Hypothesis 1, for the perceived restorative qualities (being away, fascination) we expect:

a. That ratings will decrease linearly in the following order for the sounds: Nature sound, quiet, broadband noise and office noise (i.e. a main effect of sound),
b. That the nature setting will draw higher ratings than the office setting (i.e., a main effect of setting), and
c. That the linear decline will be steeper for the nature setting (i.e., an interaction between sound and setting).

Hypothesis 2, for restoration likelihood we expect (a) a main effect of sound, (b) a main effect of setting, and (c) an interaction between sound and setting as described for Hypothesis 1.

Hypothesis 3, for the attitude toward the setting we expect (a) a main effect of sound, (b) a main effect of setting, and (c) an interaction between sound and setting as described for Hypothesis 1.

Methods

Design and participants

To test these hypotheses we conducted an experiment with four auditive stimuli (nature sound, quiet, broadband noise, office noise) × two visual stimuli (open-plan office; urban nature environment) varied within subjects. These made up eight sound settings combinations (hereinafter simply "settings").

The participants were 49 students (27 female; mean age = 24.1) recruited from the University of Gävle. Eight participants were excluded before analysis, as they had reported having tinnitus or that they had not heard any sound during the experiment. One participant was excluded for not following the instructions, which left 40 participants for the analysis. The participants were rewarded with one cinema ticket.

Material

Scenario for cognitive fatigue

We manipulated the condition antecedent to the presentation of the settings, by asking the participants to follow a scenario

in imagining themselves as attentionally fatigued. We used the scenarios by Staats and Hartig.[20] For the attentional fatigue scenario, the text read as follows: "This semester you have studied intensely. Now, at the end of the week of exams, you really have had it. You have difficulty concentrating and are very irritable." This given scenario was always repeated before the rating tasks (i.e. that followed the presentation of each setting).

Auditive stimuli

In the experiment we tested four auditive stimuli, which were picked from a pilot study ($n = 12$) according to the participants´ attitudes toward the sounds and the rated restorative quality of the sound (i.e., these measures correlated). One sound was selected for having a low mean of restorative quality (office noise), one for having a high mean (nature sound), and two for having means in-between the other two (broadband noise; quiet). The sound stimulus were:

1. Office noise, which consisted of speech, clutter, ventilation, telephone signals, printers, coffeemakers and paper sorter machines.
2. Broadband noise, which consisted of red noise (unevenly distributed over frequencies).
3. Quiet, where no sounds were added; however, the ventilation sound from the test room was approximately 30 dBA with headphones on.
4. Nature sound, which consisted of wind sighing in the trees and twitter of birds. The sound stimuli were presented by headphones at approximately 60 L_{Aeq}.

Visual stimuli

In the experiment we tested two visual stimuli [Figure 1], which were picked from a pilot study according to the participants' attitudes toward them, and for having contrasting environments to show, which could be accessible at offices for restoration. The ratings of the office picture revealed a moderately negative attitude in the pilot study and the ratings of the urban nature picture revealed a moderately positive attitude. These moderate ratings (e.g. no ceiling or floor effect) leave the way open for auditive influence. The pictures were shown on a computer screen (size 26 cm × 17 cm) which was placed in front of the participants at the distance of approximately 50 cm.

Figure 1: Picture settings used in the study. Urban nature environment (left), open-plan office (right)

Measures

After the presentation of each setting, 13 statements followed where the participants were asked to rate the extent to which their experience matched the statements. The scales for the items ranged from 1 (not at all) to 7 (very much). Note that, we also included measures, which intended to provide additional insight into how ratings of energy, stress and affect varied with setting (not described below). Analyses involving data from those measures are beyond the scope of the present paper as they do not add something new to the pattern demonstrated here, and in the interests of conserving space we do not describe those measures here. Contact the authors for additional information.

Checks on the fatigue scenarios

The first time the fatigue scenario was presented, ten control questions followed. These questions have been used in previous studies[20,21] and were included to check whether the participants understood and could follow the given scenario manipulation. Participants were asked to complete four items for affective state (feeling irritated, tired, worn out, mentally exhausted) and four items describing fatigue behaviors (Would you be able to concentrate, make a well-balanced decision, foresee the implications of a complex situation, pay attention to a long lecture) and two items describing the need for restoration (It would be appealing to: Rest, to recharge my batteries). In the results section the items are grouped together (mean response) into the following variables: Feelings of fatigue ($\alpha = 0.75$), fatigue behavior (reversed scale; $\alpha = 0.66$) and restoration needs ($\alpha = 0.80$). Cronbach's alpha for all items grouped together was also acceptable ($\alpha = 0.72$).

Restorative qualities of the sounds

To measure the restorative qualities of the settings we used items from the perceived restorativeness scale,[19] which are based on ART. Participants were asked to complete two items for fascination (My attention was drawn to many interesting things in the presented setting; There was much to explore and discover in the presented setting) and two items for being away (Spending time in the presented setting for 20 min would give me a good break from my day-to-day routines; In the presented setting I would get away from the things that usually demand my attention). Cronbach's alpha for fascination was good for all settings ($\alpha \geq 0.80$) and before the main analysis these items were grouped together (mean response). For being away Cronbach's alpha varied between low values ($\alpha = 0.50$–0.68) and acceptable values ($\alpha \geq 75$) for the different settings. The low alpha values were dependent on consistent low ratings for both items (i.e. with limited variation it is difficult to find a correlation). Before the main analysis, the two items for being away were grouped together (mean response).

Restoration likelihood

Restoration likelihood was rated for each setting, given the condition of mental fatigue. Two items (After experiencing the presented setting for 20 min I would feel that I had: Come to rest, renewed my energy) were selected from statements used previously to investigate evaluation- and likelihood judgments of restoration and stimuli outcomes.[21] Cronbach's alpha was acceptable ($\alpha = 0.74–0.86$) for all settings except from the open-plane office picture combined with office noise ($\alpha = 0.23$). A possible explanation for the low alpha value was the consistent low ratings of both items, which gave low variance. The two items for restoration likelihood were grouped together (mean response) before the main analysis.

Attitude toward the presented setting

To measure the attitude toward being in the presented settings, given the condition of mental fatigue, items from Staats *et al*.[21] were selected, (I find the presented setting: Pleasant, annoying, attractive). Cronbach's alpha for the different settings (with reversed scale for "annoying") was between 0.68 and 0.92, which can be considered acceptable. The three items for attitude ratings were grouped together (mean response) before the main analysis.

Control and background questions

Five control questions were given after the presentation of each setting and subsequent ratings. In the control questions the participants were asked to rate how easy or difficult it was to experience themselves as mental fatigued, and if they were familiar with a given condition. The scales ranged from 1 (not at all) to 7 (very easy/familiar). Participants were also asked to rate how the given condition of fatigue mirrored their factual condition of that day, on a scale ranged from 1 (not at all) to 7 (very much). Further, participants were asked to rate how clear the statements were and the instructors before the experiment, on a scale ranged from 1 (not at all) to 7 (very clear).

At the end of the experiment, participants were asked to answer some background questions. These questions concerned the participant's: Age, gender, study area, and if any sound was heard during the experiment. They also answered if they perceived themselves as having normal hearing, being noise sensitive and suffering from tinnitus. For the questions concerning sound, hearing, noise sensitivity and tinnitus the answer options were "yes" or "no," and for the other questions participants wrote their own answer.

Procedure

Data collection took place in sound proof rooms, and the participants wore headphones during the experiment. After the fatigue scenario had been presented, the participants were asked to answer the control questions of the fatigue scenario. Next the eight settings were presented, each followed by 13 statements. The settings were counterbalanced by using a Latin square (with eight presentation orders) to minimize order effects. Each presentation order was presented five times (i.e. 5×8).

Every time before a new setting was presented; participants were presented with the fatigue scenario, followed by the information: "For a short while you will be presented to a setting. Imagine yourself in a given condition and that you are sitting down and experiencing the presented setting for 20 min." Participants were exposed for each setting during 60 s. When the urban nature environment was presented, the information that the participant experienced the setting from a window was added. This was made to increase realism as office noise was presented in some conditions, and the participants were de facto seated indoors. Earlier arguments that nature environments have restorative effects, even though we experience them from the window, support this set-up.[22,23] However, we did not think it was necessary to add information when the office environment was presented with nature sounds, as there are companies which introduce nature sounds indoors either as masking in open-plan offices, or as sound showers for relaxation. Further, we expected that the broadband noise would be interpreted as water, or masking noise, dependent on the presented picture. When all conditions were presented, the participants were asked to complete the control and background questions. The whole procedure took about 22-30 min.

Statistical analyses

IBM SPSS Statistics for Windows (Version 20.0. Armonk, NY: IBM Corp.) was used for statistical analyses. To test the hypothesis we used repeated measures analyses of variance (RM-ANOVA) with 4 (sound) × 2 (picture) settings as within-subjects factors. The linear trend-components were in focus, and we checked if these trends were free from order effects. There was no significant influence of presentation order on the linear trends ($P > 0.05$). We also included gender as a between-subjects factor, but there were no significant effects of gender on the linear trends ($P > 0.05$) and for simplicity of presentation we report no results concerning gender here.

The degrees of freedom are corrected (i.e., Greenhouse-Geisser) in the univariate analyses when the requirements on the sphericity were not fulfilled. We report the estimated marginal means from SPSS together with the standard error of the means (SEM). We used the repeated contrasts procedure to assess differences between sounds in the predicted order (Hypothesis 1-3 a) and to assess the magnitude of the differences between the linear trends (Hypothesis 1-3 c). We also calculated Pearson's correlation coefficients to check if the measures applied in the present study correlated.

Due to technical problems during data collection, high ratings (i.e. 6-7) for the control questions were not saved for the first nine participants. The first nine participants also lacked the

control question concerning their actual fatigue condition of that day. Due to high ratings from all of the other participants in the experiment, we have not further considered these non-saved responses of the control questions.

Results

Checks on the fatigue scenarios

We assumed that the participants answered the questions according to a manipulated condition of cognitive fatigue. In Table 1 we report the manipulation check of the fatigue scenario. The high mean values indicate that the participants associated general experiences of fatigue, difficulties to perform behaviors that required directed attention and high restoration needs, given the fatigue scenario. This indicated that the fatigue manipulation was understood and could be applied in ratings.

Further, as shown in Table 2, the control questions at the end of the experiment indicated that the participants could imagine themselves in a condition of cognitive fatigue, and they reported substantial familiarity with the fatigue condition. We also checked the clarity of the instructions and questions. As shown in Table 2, the mean values indicate high clarity for both items.

Restorative qualities of the settings

The ratings of restorative quality of the settings (being away, fascination) are presented in Figure 2a and b, showing a marked variation over scale range (i.e. ratings from 1 to 7). In line with Hypothesis 1a, the nature sound was rated highest for both being away and fascination, with decreased restorative quality ratings for the other sound conditions, in the following order: Quiet, broadband noise, and office noise. A RM-ANOVA with sound stimuli and picture stimuli (4 × 2) as within-person factors, confirmed this linear trend of the sounds to be significant for being away, F (1,39) = 259.94, $P < 0.001$, partial $\eta^2 = 0.87$, and fascination, F (1,39) = 16.28, $P < 0.001$, partial $\eta^2 = 0.29$. Subsequent follow-up tests also were consistent with the hypothesis that nature sounds overall should be rated higher for being away compared to quiet; F (1,39) = 19.96, $P < 0.001$, partial $\eta^2 = 0.34$; that quiet should be rated higher compared with broadband noise; F (1,39) = 30.09, $P < 0.001$, partial $\eta^2 = 0.44$; and that broadband noise should be rated higher compared to office noise; F (1,39) = 18.12, $P < 0.001$, partial $\eta^2 = 0.32$.

The subsequent tests did not show that the nature sound was rated higher for fascination compared to quiet ($F < 1.4$), however, quiet was rated higher compared to broadband noise; F (1,39) = 17.01, $P < 0.001$, partial $\eta^2 = 0.30$. Moreover, broadband noise was not rated higher compared to office noise ($F < 1.4$). This implies that the nature sound and quiet were judged to be about equally fascinating while the broadband noise and office noise were judged to be significantly less fascinating.

In line with Hypothesis 1b, the participants rated being away and fascination as more likely for the urban nature setting than

Table 1: Control of the fatigue scenarios

Feelings of fatigue		Fatigue behavior		Restoration needs	
Mean	SD	Mean	SD	Mean	SD
5.7	1.1	4.9	1.0	6.4	1.1

The scale reached from 1 (not at all) to 7. High values indicate more fatigue.
SD = Standard deviation

Table 2: Mean values and SDs for the control questions concerning the fatigue scenario and instructions

Control question	Mean	SD	*n*
Easy to imagine condition	5.4	1.4	34
Familiar with the condition	5.7	1.2	32
Clarity of the questions	6.1	1.0	32
Clarity of the instructors	6.3	1.2	33

The scale reached from 1 (not at all) to 7. SD = Standard deviation

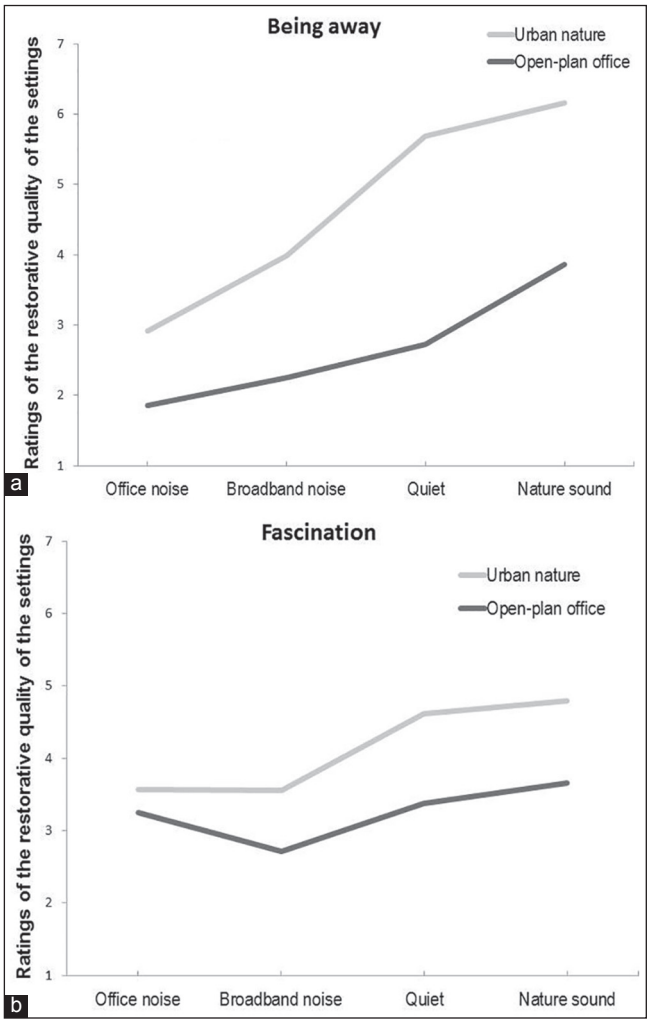

Figure 2: (a) Ratings of the restorative quality being away, for the four sound settings split over the two pictures. The scale reached from 1 (not at all) to 7 (very much) (b) Ratings of the restorative quality fascination, for the four sound settings split over the two pictures. The scale reached from 1 (not at all) to 7 (very much)

for the office setting. The analysis confirmed a main effect of picture setting on ratings of being away, F (1,39) = 103.43, $P < 0.001$, partial $\eta^2 = 0.73$, with a higher mean value for the urban nature picture ($M = 4.7$; SEM = 0.2) compared to the open-plan office picture ($M = 2.7$; SEM = 0.2). Further there was a main effect of picture on ratings of fascination, F (1,39) =13.2, $P < 0.001$, partial $\eta^2 = 0.25$ (urban nature picture, $M = 4.1$; SEM = 0.2; open-plan office picture, $M = 3.3$; SEM = 0.2).

The interaction between sound and picture setting was, however, not completely in line with Hypothesis 1c, although the interaction was significant for both being away, F (3,117) = 10.35, $P < 0.001$, partial $\eta^2 = 0.21$, and fascination, F (3,117) = 3.37, $P < 0.05$, partial $\eta^2 = 0.08$. The interaction is based on the differences between the linear trends for being away, F (1,39) =14.82, $P < 0.01$, partial $\eta^2 = 0.28$, and fascination, F (1,39) = 7.28, $P < 0.01$, partial $\eta^2 = 0.16$.

In contradiction to Hypothesis 1c, subsequent tests of being away revealed that quiet (and not nature sound) was the most influential sound condition when the difference between the urban nature and open-plan office pictures were analyzed. The magnitude of the differences between the pictures when presented in quiet, was significantly larger than the magnitude of the differences between the pictures when presented with nature sounds F (1,39) = 4.8, $P < 0.05$, partial $\eta^2 = 0.11$. However, the other settings followed our expectations (for being away), showing that the magnitude of the differences between the pictures when presented with office noise is significantly less than the magnitude of the differences between the pictures when presented with broadband noise F (1,39) = 4.92, $P < 0.05$, partial $\eta^2 = 0.11$; and that the magnitude of the differences between the pictures when presented with broadband noise is significantly less than the magnitude of the differences between the pictures when presented in quiet; F (1,39) = 9.24, $P = 0.05$, partial $\eta^2 = 0.19$.

Moreover, in contradiction to Hypothesis 1c the subsequent tests of fascination showed no significant differences, when the magnitude of the differences between the pictures were tested in a step wise comparison of the settings (*repeated contrasts*), (all $F < 3$).

In summary, the linear trends of the sounds indicate that the sounds have different degrees of restorative qualities, according to ART´s being away and fascination. However, contrary to our expectations, for being away the magnitude of the differences between the urban nature and open-plan office settings was largest when quiet (and not nature sound) was presented.

Restoration likelihood

The ratings of restoration likelihood are presented in Figure 3, showing a large variation over scale range. In line with Hypothesis 2a, the participants rated the total likelihood of restoration as high when they heard nature sounds. For the other sound settings, there was a decreased likelihood of restoration in the following order: Quiet, broadband noise and office noise. The RM-ANOVA with sound stimuli and picture stimuli (4 × 2) as within-subjects factors showed this linear trend of the sounds to be significant, F (1,39) = 279.55, $P < 0.001$, partial $\eta^2 = 0.88$. Further, subsequent follow-up tests indicated that the likelihood for restoration was higher with nature sounds compared to quiet; F (1,39) = 15.99, $P < 0.001$, partial $\eta^2 = 0.29$; that restoration likelihood was higher with quiet compared with broadband noise; F (1,39) = 45.25, $P < 0.001$, partial $\eta^2 = 0.54$; and with broadband noise compared with office noise; F (1,39) =13.93, $P = 0.001$, partial $\eta^2 = 0.26$.

In line with Hypothesis 2b, the participants expected restoration to be more likely for the urban nature setting than for the office setting. The analysis confirmed a main effect of picture on ratings of restoration likelihood in the settings, F (1,39) = 219.54, $P < 0.001$, partial $\eta^2 = 0.85$, with a higher mean value for the urban nature picture ($M = 4.1$; SEM = 0.1) compared with the open-plan office picture ($M = 2.2$; SEM = 0.1). Further, the analysis showed a significant interaction between sound and picture setting, which was not completely in line with Hypothesis 2c, F (3,117) = 18.00, $P < 0.001$, partial $\eta^2 = 0.32$.

Subsequent follow-up tests showed as expected that the magnitude of the differences between the pictures when presented with office noise is significantly less than the magnitude of the differences between the pictures when presented with broadband noise F (1,39) = 9.38, $P < 0.05$, partial $\eta^2 = 0.19$; and that the magnitude of the differences between the pictures when presented with broadband noise is significantly less than the magnitude of the differences between the pictures when presented in quiet; F (1,39) =

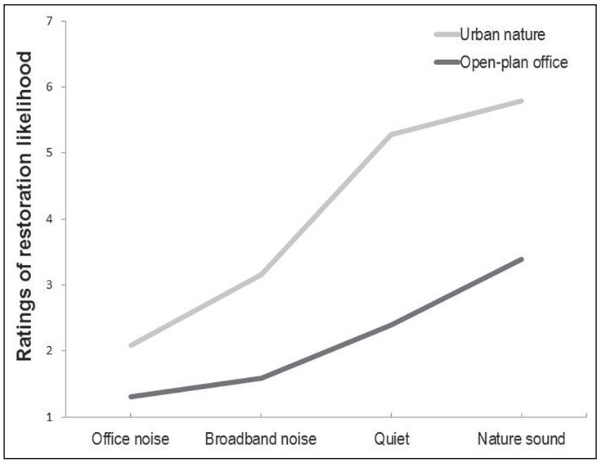

Figure 3: The estimated restoration likelihood defined by sound setting and picture. The scale reached from 1 (not at all) to 7 (very much)

17.13, $P = 0.001$, partial $\eta^2 = 0.31$. However, the magnitude of the differences between the pictures when presented in quiet was not significantly different from the magnitude of the differences between the pictures when presented with nature sounds ($F < 2.2$).

In summary, contrary to our expectations the differences in restoration likelihood between the settings were largest in magnitude when either nature sound or quiet was presented; and as we expected the settings differed least when office noise was presented.

Attitude toward the presented setting

The attitude ratings presented in Figure 4, also show a large variation over scale range. In line with Hypothesis 3a the sounds were of significance for how appealing the participants experienced the settings. The nature sound was overall experienced as strongly positive, followed by the other sound conditions, in the decreasing order: Quiet, broadband noise and office noise. The RM-ANOVA with sound stimuli and picture stimuli (4 × 2) as within-subjects factors showed that the linear trend of the sounds were significant, F (1,39) =283.16, $P < 0.001$, partial $\eta^2 = 0.88$. Subsequent follow-up tests also showed that the nature sounds overall were experienced as more positive compared with quiet; F (1,39) = 14.26, $P = 0.001$, partial $\eta^2 = 0.27$; that quiet was experienced more positive compared with broadband noise; F (1,39) = 64.56, $P < 0.001$, partial $\eta^2 = 0.62$; and that broadband noise was experienced more positive compared to office noise; F (1,39) = 11.13, $P = 0.002$, partial $\eta^2 = 0.22$. In line with Hypothesis 3b, the participants had a more positive attitude towards the urban nature setting than towards the office setting. This was shown by the significant main effect of picture on the attitude towards the environment, F (1,39) = 223.80, $P < 0.001$, partial $\eta^2 = 0.85$; with a higher mean value for the urban nature picture ($M = 4.7$; SEM = 0.1) compared to the open-plan office picture ($M = 2.5$; SEM = 1.1).

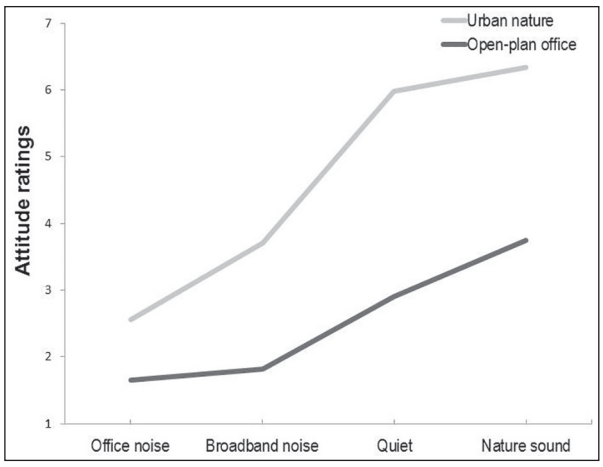

Figure 4: Ratings of attitude defined by sound setting and picture. The scale reached from 1 (not at all) to 7 (very much)

Further, there was a significant interaction between sound and picture, F (2.5, 96.8) = 17.83, $P < 0.001$, partial $\eta^2 = 0.31$. The interaction is also shown in the differences between the linear trends, F (1,39) = 54.6, $P < 0.001$, partial $\eta^2 = 0.58$. However, the interaction was not completely in line with Hypothesis 3c. The differences in attitudes towards the pictures were lowest when office noise was presented, while unexpectedly the difference between pictures was highest when either quiet or nature sound were presented. Subsequent tests confirmed that the magnitude of the differences between the pictures when presented with office noise is significantly less than the magnitude of the differences between the pictures when presented with broadband noise; F (1,39) = 13.76, $P < 0.001$, partial $\eta^2 = 0.26$; and that the magnitude of the differences between the pictures when presented with broadband noise is significantly less than the magnitude of the differences between the pictures when presented in quiet; F (1,39) = 14.56, $P < 0.001$, partial $\eta^2 = 0.27$. However, the magnitude of the differences between the pictures when presented in quiet was not significantly different from the magnitude of the differences between the pictures when presented with nature sounds ($F < 1.8$).

Further, we assessed the degree of correlation between the measures applied in the present study [Table 3]. For each setting, we found that the attitude toward the setting correlated positively and significantly with the likelihood of restoration (all $r > 0.45$) and the feeling of being away there (all $r > 0.33$), though not always with fascination. Fascination only correlated with the likelihood of restoration for three out of eight settings (the office picture presented with nature sound ($r = 0.39$); and the nature picture presented with broadband noise ($r = 0.62$); or with office noise [$r = 0.49$]). The lack of correlation for the other five settings might be due to the restriction of range in the fascination scores. The two restorative components being away and fascination are, though, significantly correlated in five of the settings [Table 3].

Discussion

The purpose of this study was to investigate whether auditory stimuli are perceived to have restorative components, and to test if there is an interaction between auditory and visual stimuli on perceived likelihood of recovery and attitudes toward the experienced settings. More specifically, we tested four auditory stimuli (nature sound, quiet, broadband noise, office noise) and two visual stimuli (overlooking an open-plan office, or a view of an urban natural environment).

Our study was influenced by ART, which refers to being away and fascination as components of restorative experience. To provide an appropriate framework for the assessment of the settings for their restorativeness, we first manipulated the condition antecedent to perceiving the different settings,

Table 3: Correlations (Pearson's *r*) between the measures: attitude, restoration likelihood (restoration), being away and fascination, for each setting

Setting	Attitude	Restoration	Being away	Fascination
Office noise with office picture				
Attitude	1	1	1	1
Restoration	0.468**			
Being away	0.328**	0.182		
Fascination	0.255	0.177	0.541**	
Office noise with nature picture				
Attitude	1	1	1	1
Restoration	0.693**			
Being away	0.516**	0.633**		
Fascination	0.294	0.392*	0.453**	
Broadband noise with office picture				
Attitude	1	1	1	1
Restoration	0.538**			
Being away	0.56**	0.311		
Fascination	0.101	0.169	0.17	
Broadband noise with nature picture				
Attitude	1	1	1	1
Restoration	0.876**			
Being away	0.786**	0.727**		
Fascination	0.610**	0.617**	0.565**	
Quiet with office picture				
Attitude	1	1	1	1
Restoration	0.763**			
Being away	0.563**	0.716**		
Fascination	0.183	0.255	0.362*	
Quiet with nature picture				
Attitude	1	1	1	1
Restoration	0.632**			
Being away	0.418**	0.676**		
Fascination	0.430**	0.137	0.033	
Nature sounds with office picture				
Attitude	1	1	1	1
Restoration	0.767**			
Being away	0.663**	0.792**		
Fascination	0.609**	0.49**	0.417**	
Nature sounds with nature picture				
Attitude	1	1	1	1
Restoration	0.724**			
Being away	0.487**	0.58**		
Fascination	0.220	0.194	0.287	

*Correlation is significant at the 0.05 level (two-tailed), **Correlation is significant at the 0.01 level (two-tailed)

by asking the participants to follow a scenario in imagining themselves as being attentionally fatigued.

Restorative qualities of the sounds

In line with our expectations, this study showed that the acoustic settings were perceived to contain varying degrees of restorative qualities, based on ART's components: Being away and fascination. The main effect of sound was strongly linear and in line with our hypothesis, that fascination and being away, to a greater extent, was perceived with the nature sound and was lower for the other sound conditions in the following order: Quiet, broadband noise and office noise. Subsequent tests of the differences between the sounds showed, however, that nature sounds and quiet were judged to be about equally fascinating, and broadband noise and office noise were judged to be significantly less fascinating than the other two sound conditions. Our interpretation is that both quiet, and nature sounds, such as wind sighing in the trees and twitter of birds have high potential to promote fascination and a feeling of cognitive distance from daily responsibilities, which can promote rest for the cognitive processes involved in directed and controlled attention. This result is in line with previous research demonstrating restorative qualities of nature environments[24,25] and bird sounds specifically.[26] Ratcliff *et al*.[26] showed that the perceived restorative benefits of bird sounds varied between bird species, as well as between participants. It is, therefore, important to note that natural sounds may generate different appraisals dependent on, for instance, acoustic properties, familiarity, habituation and associations of the individual. Consequently, quiet areas might offer better restorative qualities as there are no sounds that can interfere with the visual perception. We also found some support for this idea when we analyzed the interaction between sounds and settings. The quiet condition, and not the nature sound, gave the largest difference in perception of being away, when the urban nature and the open-plan office pictures were compared.

Effects of auditive and visual stimuli

The participants also perceived varying degrees of restoration likelihood for the settings and their attitudes toward the settings changed, dependent on which sound was presented. Notably are the relatively strong effect sizes overall.

To begin with, we found a main effect of sound that was strongly linear. Subsequent tests showed that the high ratings decreased in the following order of restoration likelihood and pleasantness: Nature sound, quiet, broadband noise and office noise. The results were, therefore, in line with our expectations and consistent with previous studies which show that nature sounds have more restorative potential than ambient noise, or office noise.[3,6,8]

For the visual stimuli, we found that the urban nature picture was more appealing to the participants and had higher likelihood for restoration than the open-plan office picture, which was also in line with our expectations and previous research.[23]

Further, we found that the auditive and visual stimuli interacted, in such a way that the initial differences between the pictures increased, the more restorative qualities the

sounds had. That is, the urban nature picture was more sensitive to the influence of auditory stimuli than the office picture. However, unexpectedly the subsequent tests showed that the quiet and the nature sound conditions are not differed significantly in magnitude (in perceived restoration likelihood and pleasantness ratings) when the differences between the two picture settings were compared. This lack of dissimilarity goes in line with our previous results concerning the settings restorative qualities and contradicts our interaction hypothesis. Still, as we expected, the nature picture was perceived as less restorative when a sound with less restorative qualities was added (i.e. broadband noise, office noise). This gives support to the idea that an urban park surrounded by noise might not be that restorative as a setting which is quiet, or where natural sounds are prominent.

Furthermore, our follow-up analyzes showed that the greater the perceived likelihood for restoration was for a setting, the more positive the participants became toward it. This confirms the results from previous studies showing a connection between restoration likelihood and attitudes.[20,21]

Further research

It is important to note that a high rating of restoration likelihood not necessarily coincide with factual restoration (see also Staats *et al*.[21]). For instance, when you visit an environment it is not certain that the environment provides the expected restorative qualities. According to ART, the likelihood of restoration is increased if there is a good correspondence between what a person wants to do and what the environment allows and requires. Therefore, if a citizen´s need for restoration conforms to the qualities of the environment, the possibility increases that actual restoration will occur.

Furthermore, it is important to test whether it is sufficient to add a nature sound to a setting to promote actual restoration. The results of this study suggest so, however, it might be that a sound taken away from its real setting, and played elsewhere, does not have the same potential to promote restoration. There is, therefore, an issue about how participants have interpreted the simulated settings. For example, the combination office view with nature sounds, but also the nature view with broadband noise may be experienced as unrealistic. Nonetheless, there is a framework for the present study as there are companies marketing sound showers with nature sounds and nature DVD: S to use indoors at offices for relaxation. Anyhow, it is important to remember that the interpretation of the sound is relevant to how the environment is evaluated. Bergman *et al*.[27] showed that priming of different images before noise exposure altered annoyance ratings depending on what meaning the picture denoted to the subsequent sound. Unfortunately, though, we did not check whether the participants could imagine themselves being in our presented settings and if they, for example, interpreted different meanings to the broadband noise dependent on setting. Since we do not know the degree to which participants could imagine themselves to be in the simulated settings, this might influence the interpretation of the results in a way we now have no access to. A somewhat different way of looking at our results would be to compare the congruous and incongruous sounds with the control condition (no sound) and see how the sound (congruous/incongruous) conditions deviate from the control condition. However, that is beyond the scope of the present paper and should serve as the impetus for further research.

Conclusions

The present study provided information about which sounds are perceived to have restorative qualities and possibilities to promote, or restrain restoration. The noise-level increments at workplaces and in urban areas request compensatory strategies that include possibilities to access restorative environments. Research in environmental psychology suggests that people´s desire for contact with nature serves an important restorative function. The challenge for modern societies is to design communities that balance settlement density with satisfactory access to nature experiences.[13] The burdens of urban noise and the restorative potential of nature sounds and quiet areas are important health issues that need to be further addressed in relation to these concerns.

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Address for correspondence:
Dr. Helena Jahncke,
Centre for Musculoskeletal Research, Department of Occupational and Public Health Sciences, Faculty of Health and Occupational Studies, University of Gävle, SE-801 76 Gävle, Sweden.
E-mail: helena.jahncke@hig.se

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