Natural Sound Facilitates Mood Recovery

Jacob A. Benfield, B. Derrick Taff, Peter Newman, and Joshua Smyth


Abstract
Visual exposure to natural scenes can aid in recovery from stress, attentional fatigue, and physical ailments including surgery and sickness. Yet little is known about what role auditory stimuli may play in restorative processes. The current study extends prior work on the benefit of natural visual scenes to the domain of natural auditory exposure. Undergraduate students (N = 133) were exposed to an unsettling video and reliably reported worsened affective state on the Brief Mood Introspection Scale (BMIS) immediately following the stimuli. Participants were then randomly assigned to either a natural sounds condition or to a comparison condition that was natural sounds intermingled with anthropogenic sounds (human voices or motorized vehicles). Participants exposed to a brief period of natural sounds following the video showed greater mood recovery, as measured by the BMIS, than did those exposed to the same stimuli also containing human-caused sounds (voices or motorized vehicles). This evidence suggests potential research avenues for examining the impact of soundscapes on cognition, stress, behavior, and a range of other health-related and well-being–related processes and outcomes.

Key Words: Environmental psychology—Biophilia.

Research has consistently demonstrated that visual access to natural environments facilitates attention restoration, improves mood, and can enhance physiological stress recovery and health more generally (e.g., Berman et al., 2008; Devlin & Arneill, 2003). For example, Tennessen and Cimprich (1995) showed that college students who viewed natural window scenes from their resident hall room scored higher on multiple measures of directed attention and reported having greater focus. Likewise, Benfield, Rainbolt, Bell, and Donovan (2014) showed that students in course sections with a natural window view performed better over the length of a semester than students in the same course but with a concrete wall window view.

Related to health, stress, and physiological recovery, seminal work by Roger Ulrich (1984) showed that natural views could speed recovery from gall bladder surgery while also reducing pain medication usage and negative interactions with hospital staff. Similar health-promoting and/or stress-reducing effects have been shown for laboratory participants (Laumann et al., 2003), prisoners (Moore, 1981–1982), dental patients (Heerwagen, 1990), office workers (Kaplan, 1993; Shin, 2007), and those living within a 3 km radius of green spaces in cities (van den Berg et al., 2010).

Conversely, research has shown that viewing urban, or man-made, environments typically does not produce these same restorative effects. For instance, Taylor, Kuo, and Sullivan (2002) showed that inner-city girls who had an exclusively urban view from their residence exhibited lower levels of concentration and impulse inhibition and lessened ability to delay gratification compared to those with an urban view containing green spaces. Hartig and colleagues (2003) showed that urban walks did not result in the reduced blood pressure typically observed in response to walking in natural settings. This research also showed that participants in the urban walking condition showed decreased performance on attention tasks, as well as lessened positive affect and greater anger when comparing pre-urban to post-urban exposure (Hartig et al., 2003). Additionally, much of the research cited previously in support of natural views (e.g., Berman et al., 2008; Laumann et al., 2003; van den Berg et al., 2010) has utilized an urban environment as a comparison environment when quantifying the restorative benefits of nature, thus directly demonstrating a lessened restorative potential for urban stimuli. In sum, emerging evidence suggests that looking at natural environments is potentially physically and/or mentally beneficial; in contrast, looking at man-made or urban elements is often not beneficial and, sometimes, even detrimental.

The auditory environment: soundscapes
Although humans rely heavily on vision when it comes to information gathering and processing, emerging research related to...
auditory environments, or “soundscapes,” has shown that auditory experiences of the environment are also important. For example, researchers have shown that the presence of human-caused or urban sounds from automobiles, aircraft, or voices can have deleterious effects on memory (Benfield et al., 2010), scenic evaluations (Weinzierl et al., 2014), affective state (Mace et al., 1999), and responses to historical park tours (Rainbolt et al., 2012).

Unfortunately, very little research on soundscapes has evaluated the potential positive effects of natural soundscape exposure. Some research suggests that these sounds are, at the very least, perceived to be beneficial. For example, Ratcliffe, Gatersleben, and Sowden (2013) conducted semistructured interviews with adults regarding their perceptions of what makes an environment restorative. From those interviews, the sound of birds singing was isolated as the most salient component of natural sounds leading to stress reduction and attention recovery. Along similar lines, research by Payne (2008, 2013) conducted in urban parks shows that individuals in urban parks classified natural sounds as being perceived as more restorative and rated different soundscapes as more or less restorative based largely on the amount of audible natural sounds. In all these cases, the actual restorative potential of the sounds was left untested, and the results instead speak to perception of sounds as either restorative or not. Although important and intriguing, it is crucial that this work be extended to include outcomes that better capture actual experiences; we now turn to such evidence and remaining gaps in the knowledge base.

Jahncke, Hygge, Halin, Green, and Dimberg (2011) explored the negative effects of office noise but also included a natural sound restoration condition. In this study, a 2 hr office sound exposure manipulation was preceded and followed by physiological (urinary catecholamines, salivary cortisol) and cognitive (recall, inhibition, attention, comprehension, logic, memory) measures to assess the consequences of open-office noise. Contrary to several of the predictions made, office noise exposure was shown only to be detrimental to performance on memory tasks.

An additional 7 min “restoration period” occurred after the post-office noise assessment as an initial test of treatments for office noise exposure, including treatments of exposure to natural sounds or silence (Jahncke et al., 2011). Additional post-restoration measures of cognition performance and stress hormones were taken, but little evidence of improved restoration was shown. Specifically, those in the natural sound condition, when compared to the office noise restoration condition, self-reported less fatigue and more motivation but showed no differences in physiology or cognitive performance. Interestingly, results of this study also showed that levels of cortisol (a naturally occurring hormone in the body that increases in response to stress) decreased during the course of the office noise exposure period despite it being intended as a stressful situation. This may indicate that participants were not adequately depleted or stressed prior to the recovery period, which would account for the relative lack of observed restoration. Although this could also be due to a null restorative effect of natural sound overall, given the results of the cortisol assays (suggesting decreasing, not increasing, physiological stress), the former interpretation seems more likely. As such, the potential restorative effects of sounds are still not clearly understood and have yet to be adequately tested (e.g., subsequent to a highly stressful/arousing state).

This relative dearth of evidence regarding the restorative abilities of natural sound is particularly troubling when recreation and leisure research often shows that outdoor recreators are seeking solace from the sounds of urban living (Driver et al., 1987) or actively seeking natural quiet (Haas & Wakefield, 1998; Marin et al., 2011). Similarly, with legislative actions being taken in both the United States and across Europe to better manage noise in both natural and urban settings (e.g., Jensen & Thompson, 2004) and promote natural recreation areas as a source of health (e.g., National Park Service Health and Wellness Executive Steering Committee, 2011), the lack of research regarding the benefits of natural sounds, or the detriments of man-made sounds, fails to provide an evidence base upon which to make decisions and may expose such legislation and management plans to criticisms or legal actions.

Thus, this project examined the restorative potential of natural versus urban auditory stimuli in hopes of connecting it with prior work on restorative visual environments while also providing empirical evidence in the context of soundscapes and the benefits of nature more generally. A sample of urban participants from the Philadelphia, Pennsylvania, USA, metropolitan area participated in a 3 (time; within) × 4 (sound condition; between) experimental procedure in which all participants completed mood measures before and after both a negative mood–inducing task and one of four soundscapes as more or less restorative based largely on the amount of audible natural sounds. In all these cases, the actual restorative potential of the sounds was left untested, and the results instead speak to perception of sounds as either restorative or not. Although important and intriguing, it is crucial that this work be extended to include outcomes that better capture actual experiences; we now turn to such evidence and remaining gaps in the knowledge base.

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Method
Participants
A convenience sample of 133 participants (72 females; 61 males) was recruited from a college campus servicing the greater Philadelphia area. Participants were racially diverse (54.1% White) and of college age ($M = 19.09$, $SD = 2.12$).

Materials and procedure
Participants were recruited for a study on “Stress and the Physical Environment II” using a research participant pool from introductory-level college courses. Participants were informed that they would participate in a study “designed to explore the relationship between physical environments and individual mood, cognitive ability, and/or attitudes,” which would require them to “complete a number of tasks designed to test or manipulate cognitive ability, emotions, and/or personal attitudes while also being required to make decisions about images or sounds found in everyday life.”

Appropriate IRB approval was obtained through the Office of Research Protection at Penn State University. The approval and study protocol included the use of informed consent from all participants.

Following informed consent, participants were run through the procedure individually by one of three trained research personnel. Participants completed demographic (age, sex, race) and several other psychological questionnaires (not used in this report) before providing baseline measurements of affective state using the 16-item Brief Mood Introspection Scale (Mayer & Gaschke, 1988). This measure consists of a series of single emotional words (e.g., lively, tired) that are rated along a 4-point range from definitely do NOT feel to definitely feel. These adjectives were combined to create aggregates for Pleasant-Unpleasant (16 items; $z = .84$), Positive-Tired (7 items; $z = .74$), and Negative-Relaxed (6 items; $z = .74$).¹

Following baseline measurement, all participants were exposed to a presumptively stress-inducing video similar to that utilized in prior research (Bosch et al., 2001; Takai et al., 2004). Specifically, participants watched a 3 min video of a hand tendon replacement surgery that included close-up footage of a human hand being cut open to expose the tendon, the tendon being relocated in the hand using medical equipment, and the tendon inside the hand being sutured using a needle and thread. This video was used to create an initial state of discomfort and negative mood in participants to address the concern that prior research on sound restoration (e.g., Jahncke et al., 2011) may have failed to create a sufficiently stressful/aroused preliminary task from which participants needed to recover.

After the video, participants were again assessed using the BMIS and then randomly assigned to one of four soundscape conditions—natural sounds, natural sounds with voices, natural sounds with motorized noise, or a control condition. The natural sound condition was created from recordings taken by the US National Park Service and contained birdsong and leaves rustling in the wind. The voices and motorized noise conditions were created by adding National Park Service recordings of voices or motorized craft to the original natural sound file; the control condition contained no sound clips. All sound conditions were presented through noise-canceling headphones, which were worn during the entire experimental procedure. Sound levels were set at 45–50 dB(A), and sound exposure was limited to 3 min to assess rapidly occurring changes in affective state. No visual information was provided to accompany the sound exposure treatments; participants were instructed to focus attention on a “+” in the middle of a computer screen during the 3 min exposure task. Thus any effects observed following the restoration period would be primarily, if not entirely, based on auditory stimuli rather than visual stimuli (and, further, all visual stimuli were identical across experimental conditions).

A third and final BMIS measurement was reported immediately following the soundscape exposure. Participants were then debriefed and given research credit toward a course requirement.

Results
Initial statistical tests were conducted to verify both group equivalence at baseline (H1) and the effect of the mood manipulation video (H2). Results showed that the four experimental groups did not differ on baseline ratings of BMIS subscales (all $p > .32$) or on BMIS ratings following the mood manipulation (all $p > .30$). Additionally, results showed that all four groups’ BMIS scores were negatively affected by the video (all $p < .001$), indicating that the manipulation was effective at producing dysphoric mood. Table 1 displays descriptive statistics for all measurement occasions and conditions of the study.

To test the restorative potential of the sounds, a mixed factorial repeated measures analysis of variance (R-ANOVA) was conducted with sound condition (control, natural, voice, motorized) being predictive of changes in BMIS scores from postvideo (pre-sound exposure) to post-sound exposure. Results were supportive of the hypothesis (H3; see Table 2). Significant BMIS change by sound condition interactions was shown for both the Pleasant-Unpleasant subscale ($F = 7.62$, $p < .001$, partial $\eta^2 = .150$) and the Positive-Tired subscale ($F = 6.36$, $p < .001$, partial $\eta^2 = .126$); a marginal interaction...
between sound condition and affective restoration was also shown for the Negative-Relaxed subscale ($F = 2.18, p = .094$, partial $\eta^2 = .048$).

Follow-up analyses showed that the natural sound condition showed greater recovery from the upsetting video compared to both the control and anthropogenic sound conditions. For the Pleasant-Unpleasant score, participants in the natural condition were the only ones to show improved affect from post-video ($M = 38.89, SD = 8.22$) to post-recovery ($M = 44.31, SD = 6.95$); the other three conditions showed no significant changes from pre-recovery levels. The Positive-Tired scale showed a similar trend, with natural sound condition scores improving from pre- to post-recovery ($M = 16.20$ vs. $17.26$) and scores in other conditions either staying the same (voices) or decreasing (control and motorized).

Because the interaction between sound condition and mood recovery did not reach conventional levels of statistical significance for the Negative-Relaxed subscale, those simple effects were not reported in the text. However, the trend seen in the other two subscales was replicated; the natural sound condition resulted in greater lowering of Negative-Tired ratings when compared to the other three conditions ($\Delta M = -2.86$ vs. $-1.50$, $-1.11$, and $-1.66$ for control, motorized, and voices, respectively). These simple effects suggest that the marginal result for the interaction was largely due to all sounds showing recovery in the same direction but natural sounds doing so more effectively. As such, the effect is likely harder to detect; thus this analysis was likely statistically underpowered.

### Table 1. Descriptive Statistics for BMIS Subscale Scores Across Assessment Times and Between Sound Conditions

<table>
<thead>
<tr>
<th>BMIS SUBSCALE</th>
<th>SOUND CONDITION</th>
<th>MEAN (SD) TIME 1</th>
<th>MEAN (SD) TIME 2</th>
<th>MEAN (SD) TIME 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleasant-Unpleasant</td>
<td>Control (n=36)</td>
<td>44.52 (8.47)</td>
<td>41.44 (8.10)</td>
<td>41.78 (9.44)</td>
</tr>
<tr>
<td></td>
<td>Natural (n=35)</td>
<td>44.54 (6.86)</td>
<td>38.89 (8.22)</td>
<td>44.31 (6.95)</td>
</tr>
<tr>
<td></td>
<td>Motorized (n=32)</td>
<td>45.31 (7.49)</td>
<td>40.34 (8.50)</td>
<td>39.53 (9.04)</td>
</tr>
<tr>
<td></td>
<td>Voices (n=30)</td>
<td>46.07 (7.52)</td>
<td>40.53 (7.17)</td>
<td>42.40 (7.94)</td>
</tr>
<tr>
<td>Positive-Tired</td>
<td>Control (n=36)</td>
<td>18.81 (3.72)</td>
<td>17.25 (3.65)</td>
<td>15.97 (5.25)</td>
</tr>
<tr>
<td></td>
<td>Natural (n=35)</td>
<td>18.46 (3.59)</td>
<td>16.20 (3.55)</td>
<td>17.25 (3.86)</td>
</tr>
<tr>
<td></td>
<td>Motorized (n=32)</td>
<td>19.69 (3.41)</td>
<td>17.25 (3.45)</td>
<td>15.53 (4.32)</td>
</tr>
<tr>
<td></td>
<td>Voices (n=30)</td>
<td>19.07 (3.62)</td>
<td>16.87 (3.08)</td>
<td>16.83 (3.53)</td>
</tr>
<tr>
<td>Negative-Relaxed</td>
<td>Control (n=36)</td>
<td>13.39 (4.16)</td>
<td>13.75 (3.54)</td>
<td>12.25 (3.17)</td>
</tr>
<tr>
<td></td>
<td>Natural (n=35)</td>
<td>13.69 (3.52)</td>
<td>14.91 (3.69)</td>
<td>12.06 (3.50)</td>
</tr>
<tr>
<td></td>
<td>Motorized (n=32)</td>
<td>13.72 (3.42)</td>
<td>14.97 (3.83)</td>
<td>13.86 (3.92)</td>
</tr>
<tr>
<td></td>
<td>Voices (n=30)</td>
<td>12.47 (3.90)</td>
<td>14.53 (4.04)</td>
<td>12.87 (3.55)</td>
</tr>
</tbody>
</table>

### Table 2. Results From Repeated Measure ANOVAs for Each of the Three BMIS Subscales

<table>
<thead>
<tr>
<th></th>
<th>$F$</th>
<th>SIG</th>
<th>PARTIAL $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleasant-Unpleasant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mood</td>
<td>11.58</td>
<td>.001</td>
<td>.082</td>
</tr>
<tr>
<td>Condition</td>
<td>0.36</td>
<td>.779</td>
<td>.008</td>
</tr>
<tr>
<td>Mood x Condition</td>
<td>7.60</td>
<td>.000</td>
<td>.150</td>
</tr>
<tr>
<td>Positive-Tired</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mood</td>
<td>3.74</td>
<td>.055</td>
<td>.028</td>
</tr>
<tr>
<td>Condition</td>
<td>0.09</td>
<td>.965</td>
<td>.002</td>
</tr>
<tr>
<td>Mood x Condition</td>
<td>6.22</td>
<td>.001</td>
<td>.126</td>
</tr>
<tr>
<td>Negative-Relaxed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mood</td>
<td>46.64</td>
<td>.000</td>
<td>.266</td>
</tr>
<tr>
<td>Condition</td>
<td>1.06</td>
<td>.369</td>
<td>.024</td>
</tr>
<tr>
<td>Mood x Condition</td>
<td>2.18</td>
<td>.093†</td>
<td>.048</td>
</tr>
</tbody>
</table>

Note: Numbers in bold indicate statistically significant effect. †, marginal $p$-value.
Discussion

Based on research showing restorative effects for viewing natural scenes and related visual stimuli, the current study hypothesized that natural sounds (independent from any benefit from visual stimuli) would similarly show a positive effect on individuals' affective recovery following an upsetting experience. Consistent with that hypothesis, the data show that individuals experiencing natural sounds (in the absence of any relevant visual cues) showed enhanced mood recovery compared to those hearing no sounds or those hearing anthropogenic sounds (motorized or voices). This provides strong preliminary evidence for the restorative aspects of soundscapes on mood and has a number of implications for research and practice.

These findings directly connect to prior theoretically driven work on visually restorative natural environments, which have shown a broad range of effects on psychological processes and physiological health. Thus the effects of natural acoustic sounds on restoration may be similarly broad; that is, soundscapes may not only influence mood but also could have benefits on stress, attention, cognition, or other health and performance outcomes. Although speculative at this point, this line of reasoning leads directly to a number of intriguing research possibilities. For example, the research by Ulrich (1984) found that natural views can aid surgery recovery and pain management; it may be that exposure to natural sounds has similar effects while also being easier to implement, as a restorative soundscape could be provided in the absence of natural window views (or even windows themselves). Similarly, research on visual restoration shows that the view from a window can improve attention (Tennesen & Cimprich, 1995) or school performance (Benfield et al., 2014); natural soundscape exposure may have the same effect in these domains as well. Unfortunately, the current study focused only on reported mood recovery from an acute dysphoric state, and broader health and cognitive outcomes were not assessed. Such predictions, although based on prior research, remain to be tested in future research.

The laboratory-based nature of the study instills a high degree of experimental validity regarding the presence of the positive effect but is also limited in its generalizability to outdoor recreation settings (i.e., ecological validity). Future research focused on stress recovery and other potential benefits will need to test the real-world limits and generalizability of this restorative acoustic effect. Field experiments with urban park users or visitors to national parks would provide more ecologically valid tests, as would cross-sectional studies of responses to stressful situations taking place in different, naturally occurring soundscapes (e.g., some nature dominated and others less so).

The value of directly testing real-world environments cannot be understated. Although research has shown that technological substitutes for natural environments can be restorative (e.g., Friedman et al., 2004; Parsons et al., 1998), the value of simulations of nature may be less than that of actual environmental exposure (Kahn et al., 2008). In the context of the current study's use of simulations, the presence of an effect using a presumably weaker stimulus bodes well for research utilizing actual acoustic environments or other approaches with greater verisimilitude.

Additionally, consistent with other research on restorative visual environments, the current study examined the effects of benign, pleasant natural conditions. Such a choice allows for demonstrating the potential for restoration but does little for defining the limits of restorative natural or man-made acoustics. For instance, would natural soundscapes that are potentially indicative of danger, such as thunderstorms or predatory animal calls, elicit a different response? Likewise, would man-made soundscapes indicative of camaraderie or leisure, such as laughter or whistling a tune, provide more beneficial outcomes than the anthropogenic sounds tested in the current study? Such questions of sound characteristic, source, appraisal/meaning, individual exposure histories, and survival affordance will need to be addressed in future research.

Finally, although this study utilized a powerful manipulation of emotional state, as well as measures sensitive to changes in affective state, study outcomes were reliant on self-report. More rigorous testing of the restorative properties and potential of natural sounds should be conducted making use of biomarkers indicative of stress responses and subsequent recovery. Changes in cardiovascular parameters, stress hormone levels, and/or skin conductivity would not only be strong indicators of stress recovery but also provide a plausible biological mechanism linking these processes to manifest disease outcomes (e.g., hypertension, diabetes, and cardiovascular disease). Additionally, research examining the potential moderating role of listener restorative expectations, motivations, or attitude toward noise would also be a valuable next step in quantifying the restorative potential of natural sounds. Overall, this work provides important initial experimental evidence on the restorative properties of natural sounds and suggests many additional lines of future research.

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