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Evaluating restoration in urban green spaces: Does setting type make a difference?

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Highlights:

- An experimental comparison of the restorative impacts of an urban streetscape and three common types of urban park and woodland settings.
- Stronger recovery from emotional stress on self-reported mood and restorative state in the natural conditions as compared to the urban street condition.
- No significant differences in recovery among the three natural settings.
- Restoration in urban green space varies with individual stress reactivity and perceptions of naturalness.

1. Introduction

Urban green space can make a significant contribution to people's overall well-being and quality of life, as part of their everyday experiences (Bell et al., 2008). In particular, an expanding body of research has shown green space to have restorative effects, reducing stress and mental fatigue, enhancing people's mood and helping to prevent depression (Van den Berg, Hartig, & Staats, 2007). The relevance of these benefits is increasing due to growing urbanization, and its negative impact on mental health (Lederbogen et al., 2011; Peen et al., 2007). Nevertheless, whilst it is generally recognised that urban green space has important restorative potential for city dwellers, relatively little is known about how to plan, design and manage urban green spaces so as to optimize their restorative impact. Most research on restorative environments has compared one type of natural setting against one type of built setting (Velarde, Fry, & Tveit, 2007). To create urban green spaces with optimal restorative potential, there is a need for a more diverse sampling of environments (Frumkin & Fox, 2011; Jorgensen & Gobster, 2010). To address this need, the current study assesses the restorative impacts of different types of commonly found urban green spaces.

Natural environments are traditionally regarded as more supportive of restoration from depleted emotional and cognitive resources than built environments (Ward Thompson, 2011). The greater restorative potential of natural as compared to built environments has been described and predicted by Stress Recovery Theory (SRT; Ulrich, 1983; Ulrich et al., 1991) and Attention Restoration Theory (ART; Kaplan & Kaplan, 1989; Kaplan, 1995). Although both theories share common features, SRT has focused primarily on how nature can support affective and physiological recovery from acute 'stress' or the depletion of emotional resources, while ART

has focused on attentional restoration from 'mental fatigue' or the depletion of cognitive resources. ART distinguishes four components of restorative environments which have become the dominant framework for understanding restorative environment experiences: fascination, or the capacity of an environment to automatically draw attention without cognitive effort, a sense of extent or connectedness, being away from daily hassles and obligations, and a compatibility between individual needs and the characteristics of the environment. Although each of these components can be found in built as well as natural settings, ART contends that the combination of the four components is most typical for natural settings, hence the greater restorative potential of natural settings.

The greater restorative potential of natural as compared to built settings, particularly as reflected in improved mood, has been demonstrated in many studies (for reviews, see Bowler, Buyung-Ali, Knight, & Pullin, 2010; Thompson Coon et al., 2011; Velarde, et al., 2007). The majority of these studies have contrasted an activity in one type of natural setting to the same activity in one type of built setting, e.g. walking in a park versus walking through an urban street (Hartig, Evans, Jamner, Davis, & Gärling, 2003), working in a place with a view of trees and parks versus working in a place with a view of buildings, parked cars and paved areas (Shin, 2007); or viewing a video of a walk through a waterside environment versus viewing a video of a walk through an urban pedestrian street (Laumann, Garling, & Stormark, 2003). Differences between natural and built settings have been observed after brief exposure times of only a few minutes or less, indicating the importance of 'micro-restorative experiences' with green space in the nearby living environment (Barton & Pretty, 2010; Kaplan, 2001).

A disadvantage of the prevalent natural-built dichotomy in restorative environments research is that it does not provide guidelines on which options for urban green space design and management are most effective in providing restoration. In response to these concerns, research on restorative environments has expanded to include a more diverse sampling of different types of natural and/or built environments. Part of this expansion is being achieved by running experiments with multiple natural and/or built conditions (e.g. Antonson, Mårdh, Wiklund, & Blomqvist, 2009; Beil & Hanes, 2013; Gatersleben & Andrews, 2013; Karmanov & Hamel, 2008; Martens, Gutscher, & Bauer, 2011; Tyrväinen et al., 2014). At the same time, however, research has increasingly employed descriptive and correlational designs that allow for a more cost and time efficient measurement of the restorative potential of large numbers of settings (De Jong, Albin, Skärbäck, Grahn, & Björk, 2012; Hartig, Korpela, Evans, & Gärling, 1997; Herzog, Colleen, Maguire, & Nebel, 2003; Nordh, Hartig, Hagerhall, & Fry, 2009; Purcell, Peron, & Berto, 2001; Van Dillen, De Vries, Groenewegen, & Spreeuwenberg, 2011; White, Pahl, Ashbullby, Herbert, & Depledge, 2013).

These lines of enquiry have made some progress in identifying green space options with a high restorative potential. In terms of overall landscape type, a recent survey among a large sample of the English population revealed, among other things, that visits to rural woodlands and forest areas were associated with more recalled restoration than visits to open countryside settings and town parks (White et al., 2013). On a theoretical level woodlands and other densely vegetated green spaces would also appear to conform to all four components of restorative environments as described by ART (Kaplan & Kaplan, 1989; Kaplan, 1995): they are rich in complexity and therefore have the potential to generate fascination, the enclosing vegetation may contribute to a

sense of being away and extent, and they support many different types of activities, ensuring a high compatibility. These ideas receive some support from a study among Norwegian students, who were asked to rate videos of different types of environments, including a forest and a botanical park, on a rating scale that measures the four components of ART (Laumann, Gärling, & Stormark, 2001). The video of the forest was rated higher on fascination, being away, extent and compatibility than the video of the park.

Within the urban context, a photo perception study showed that the likelihood of restoration in small 'pocket parks' in Norwegian cities was positively related to the naturalness of the parks as measured by percentage of ground surface covered by grass and the amount of trees and bushes visible (Nordh et al., 2009). This study also demonstrated that the greater likelihood of restoration in the more natural parks could be explained by the greater sense of being away and fascination provided by these parks. The positive contribution of naturalness to the perceived restorativeness of urban green spaces is corroborated by a survey in nine Swedish cities, which revealed that green spaces exemplifying the dimensions 'refuge', 'nature' and 'rich in species' were preferred by stressed individuals (Grahn & Stigsdotter, 2009). Interestingly the main item loading onto 'refuge' was 'The park or open space contains many bushes'. A field study among visitors of green spaces in and around the English city of Sheffield found positive associations between the species richness of the areas and the perceived contribution of the green space to restoration and well-being, with the perceived benefit being most strongly related to species richness of plants and to a lesser extent of birds (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007).

While naturalness is generally a positive predictor of restoration, there is some indication that the presence of very dense vegetation may compromise restoration by evoking feelings of insecurity Dense urban woodlands have, for example, come to be seen as likely settings for physical or sexual assault and other incivilities (Jorgensen & Anthopoulou, 2007; Jorgensen, Hitchmough, & Dunnett, 2007)**.** Research has generally confirmed that fully enclosed green spaces tend to be perceived as less restorative than open or half-open spaces (Antonson et al., 2009; Han, 2010; Herzog & Chernick, 2000; Herzog et al., 2003), although a study in Finland showed that urban forests were seen as more restorative when the surrounding urban matrix was not visible through the forest (Hauru, Lehvävirta, Korpela, & Kotze, 2012). A recent experimental study in the UK demonstrated that a field or laboratory walk through an enclosed country park with unstructured, dense vegetation further increased levels of stress and attentional fatigue, while walks through a more open park promoted restoration (Gatersleben & Andrews, 2013).

Feelings of insecurity associated with dense natural settings may be mitigated by signs of tendedness or 'human care' (De Jong et al., 2012; Herzog & Chernick, 2000; Martens et al., 2011; Nordh et al., 2009). For example, a field experiment in Switzerland showed that a 30-minute walk through a tended dense forest with visible signs of maintenance fostered stronger mood improvements than a walk through an equally dense, but more wild part of the forest that had not been maintained for many years (Martens et al., 2011). It has been suggested that the presence of clear signs of maintenance enhances perceived safety because it is suggestive of the presence of friendly, caring others (Jorgensen et al., 2007), while a lack of signs of human care and control may remind people of their own mortality and vulnerability to the forces of nature (Koole & Van den Berg, 2005).

In sum, there is a body of evidence suggesting that woodlands and forest areas are associated with high perceived restoration, and that the presence of natural elements such as trees, bushes, grass and species richness is conducive to restorative experience within urban green spaces, provided that the vegetation is not so dense and wild that it creates feelings of insecurity. It is, however, important to note that most of the evidence for a positive impact of naturalness comes from studies that measured perceived restorativeness, experimental studies have often failed to demonstrate differences in actual restorative impact between natural conditions (Beil & Hanes, 2013; Sonntag-Öström et al., 2011; Tsunetsugu et al., 2013; Tyrväinen et al., 2014; Ulrich et al., 1991; Van den Berg, Koole, & Van der Wulp, 2003). This suggests that there may be a publication bias favouring studies that report differences in restoration between natural settings.

The aim of the present study was to establish whether commonly found urban public spaces with varying degrees of naturalness differ in their restorative impact. Perceived naturalness has previously been associated with vegetation structure and the presence of structural change (with tall dense vegetation seen as more natural) (Lamb & Purcell, 1990); and with the growth of scrub and woodland, a more spatially varied woodland edge, and the number of woodland patches (Ode, Fry, Tveit, Messager, & Miller, 2009). In this study we therefore interpreted naturalness as the amount and structural variety of vegetation including the number of vegetation layers. Following these considerations, we selected three types of urban green spaces with increasing degrees of naturalness: open parkland, tended woodland, and wild woods. We also included a completely built-up, unnatural urban street setting. We expected all three natural settings to be more restorative than the urban street setting.We also expected the two more ‘natural’ (i.e. more

vegetated and structurally varied) wooded settings to be more restorative than the parkland setting. With respect to the two wooded settings, we were interested to find out whether tendedness (signs of vegetation care and management) would enhance restoration by mitigating the feelings of personal insecurity that may occur in these densely vegetated and enclosed settings.

2. Method

2.1. Participants and design

The study consisted of a laboratory experiment in which participants were first exposed to a stressful video and then were randomly assigned to one of four conditions where they viewed a short, simulated walk through an urban built or green space. Participants were 102 university students (54 females), ranging in age from 17 to 40 years (mean age 22.2 years). The sample was ethnically diverse, with 58% identifying themselves as 'white', 35% as 'Asian' and 7% as 'black', 'mixed' or 'other'. The sample was recruited via email invitations sent to all students at the University of Sheffield, and represented a diverse selection of disciplines, including 10% from the Department of Landscape. Participants were approximately equally distributed across the four environmental conditions: urban street (n = 24), parkland (n = 27), tended woodland (n = 25), and wild woods (n = 26). The four conditions did not differ in gender, age, ethnicity or study background. Participation was voluntary, and participants received a payment of £10 on completion of the experiment. Ethical approval for the study was given by the Department of Landscape's Research Ethics Committee.

2.2. Environments

Four short photo/video presentations were made in PowerPoint to simulate the experience of walking through common built and natural urban spaces. Simulated walks are commonly used in restorative environments research and have been successfully applied before (Gatersleben & Andrews, 2013; Laumann, Garling, & Stormark, 2003; Van den Berg et al., 2003). The urban street presentation (Figure 1.1) showed a sequence of streets, alleys and open spaces in an historic part of the city of Sheffield. Key features of this setting were that it contained virtually no vegetation, but had a well-defined sense of enclosure provided by the buildings and streetscape. The parkland presentation (Figure 1.2) showed a part of the Sheffield Graves Park with generally mature specimen trees, pruned to remove lower branches, set in mown grass. Key features of this setting were that it contained only two vegetation layers (mature trees and mown grass), as well as being well-tended and open, so that distant elements within the park were clearly visible. The tended woodland presentation (Figure 1.3) depicted the Sheffield Botanical Gardens, a park-like woodland setting containing clumps of native and exotic vegetation consisting of trees, shrubs and ground-covering plants, separated by small mown grass glades. Key features of this setting were that the vegetation was denser and more structurally complex than the parkland, containing ground covering vegetation and shrub layers, as well as trees and mown grass, and was well-tended with a well-defined sense of enclosure. The wild woods presentation (Figure 1.4) depicted parts of Sheffield Greno Woods, a mature woodland with a number of vegetation 'layers', including a well-developed understorey of shrubs and regenerating trees and rough ground cover. This setting had roughly the same level of enclosure as the tended woodland but with a less-tended, more irregular and 'wild' appearance. People could be seen in the middle to far distance of the urban street and parkland presentations, but not in the tended woodland or wild woods. No steep slopes, water bodies or surrounding urban

185 infrastructure were visible in the presentations of the natural settings apart from brief shots of
186 parked or passing cars in the parkland and tended woodland, and of a boundary wall in the
187 tended woodland.
188
189 Each setting was photographed and filmed during a 250m walk along a road or path on a sunny
190 day in June, with pauses as if to take a closer look at the surroundings. These recordings were
191 used to create a photo/video presentation of 6 minutes and 40 seconds that simulated the walk
192 using 50 still photographs (displayed for 2 seconds each) and five 60 second film clips. A Flip
193 Ultra HD camcorder was used to create the film footage, which was inserted roughly every 8th
194 photo. Each film clip consisted of 4 x 15 second pans (two horizontal, and two vertical) filmed
195 from a stationary position on the path and simulating a look around the immediate surroundings
196 of the viewer, picking up on details e.g. of trees or buildings. Ambient sound was included with
197 the film clips to capture noise that was consistent with each site, such as people talking in the
198 distance, birds singing or the sound of rustling leaves. Background noise, such as distant traffic,
199 was deemed acceptable, but filming was restarted when an emergency vehicle sounding a siren
200 passed by.
201
202 *2.3. Measures*
203 Measurements of mood and restorative state were taken at baseline (T1), after watching the scary
204 movie (T2), and then again after viewing the simulated walk (T3). Items of the mood and
205 restorative state scales were presented in different order at each time of measurement.
206

Mood was measured by the short form of the Profile of Mood States (POMS-SF; Curran, Andrykowski, & Studts, 1995). This scale consists of 37 mood words representing six mood states named anger, tension, fatigue, confusion, depression and vigour. Participants rated the extent to which each word described the way they were feeling right now on a 7-point scale (1 = 'do not feel at all'; 7 = 'feel very strongly'). The six subscales were combined into two broad mood dimensions: 'negative mood' (computed as the weighted average of the anger, tension, confusion, and depression subscales) and 'vitality' (computed as the weighted average of the vigour subscale and the reverse coded fatigue subscale). Both scales had good reliability, Cronbach's alpha for the negative mood scale (26 items) was .90 at T1, and .95 at T2 and T3, Cronbach's alpha for the vitality scale (11 items) was .89 at T1, .80 at T2 and .88 at T3. Negative mood was weakly to moderately negatively correlated with vitality with *r*s between -31 and -.29. This suggests that the subscales are related but not redundant.

Restorative state was measured with a self-developed scale consisting of nine statements developed to monitor changes in actual restorative state over time (Table 1). Existing measures such as the Perceived Restorativeness Scale (PRS; Hartig et al., 1997) or the Restorative Components Scale (Laumann et al., 2001) all focus on the perceived restorativeness or likelihood of restoration, with items such as 'There are many objects here that attract my attention'. Essentially, these are instruments to evaluate settings, they are not suitable for measuring changes in restorative state over time. Han's (2003) Short-Term Revised Restoration Scale (SRRS) contains some state items but is not suitable overall as the other items relate to evaluative judgments of environments. Our own Restorative State Scale (RSS) was inspired by Kaplan & Kaplan's description of the restorative nature experience as sequence of interrelated

and deepening levels of restorativeness (1989, p. 196-197). We selected items that capture the overall experience (e.g. 'I feel connected to the natural world') as well as items that tap into more distinct levels or functions of the restorative nature experience such as 'clearing the head' (e.g. 'my mind is not invaded by stressful thoughts') and 'reflection on one's life and one's priorities and possibilities (e.g. 'I can make space to think about my problems'). Response options ranged from 1 = 'do not feel at all' to 7 = 'feel very strongly'. After removal of items that were weakly correlated with the other items, the 9-item RSS showed sufficient reliability, Cronbach's alpha was .63 at T1, .72 at T2, and .79 at T3. Scale scores were derived by averaging the responses. Restorative state was weakly correlated with negative mood with *r*s between -.16 and .19, and weakly to moderately positively correlated with vitality, with *r*s between .09 and .46. This indicates that the RSS is distinct from, but meaningfully related to, the more established POMS.

At the end of the experiment, participants rated the environment they had seen on a number of dimensions, including perceived naturalness, using a 7-point scale with 1 = 'not at all natural' and 7 = 'very natural'. For exploratory purposes, participants were also asked to list three keywords describing their overall reaction to the environment.

2.4. Procedure

A total of ten sessions (2-3 sessions per condition) were run with groups of 2-24 participants in the Spring semester outside of the exam period. All sessions were held in the same lecture room at the University of Sheffield. This room had no windows and was completely blacked out when the presentations were shown on a large screen of 3 x 2 m. At the start of each session, the

sequence of experimental procedures was explained, participants were required to give their informed consent, and were told that they were free to leave at any time. Following the baseline measurements of mood and restorative state, participants were exposed to an affective stressor consisting of a 14 minute excerpt from an 18+ rated scary movie. The excerpt contained sequences high in suspense depicting extremes of human emotion and graphic violence against the person set mainly inside buildings. Previous studies have effectively used similar scenes to induce emotional stress (Ulrich et al., 1991; Van den Berg et al., 2003). The stressor was followed by a second series of mood and restorative state measurements, after which the participants watched one of the four simulated walks. Participants were instructed to watch the presentation carefully, and to imagine themselves walking through the setting shown. The presentation was followed by a third series of measurements and additional questions related to the perceived naturalness and other characteristics of the environment shown. Participants then completed the last part of the questionnaire, which contained questions about gender, age, field of study and ethnicity, and a question asking for feedback and suggestions. Finally, participants were thanked, paid and their questions on the study were answered. The total duration of each session was approximately 1 hour.

2.5 Data Analysis

All analyses were carried out using SPSS for Windows version 20.0. We used one-way analyses of variance to examine differences between the conditions in baseline measurements and perceived naturalness. We performed three sets of repeated-measures analyses of variance to examine changes in negative mood, vitality and restorative state across the three times of measurement. The first set of repeated-measures analyses examined changes from T1 to T2

(stress reactivity), using condition (street, parkland, woodland, wild woods) as a between factor. The second set of repeated-measures analyses examined changes from T2 to T3 (recovery), using condition as a between factor and stress reactivity (as measured by T1-T2 change scores) as a covariate. The third set of repeated-measures analyses examined influences of perceived naturalness on recovery in the natural conditions with stress reactivity and condition (dummy-coded) as covariates. For these latter analyses, participants in the natural conditions were reallocated to three groups using a tertile split on the naturalness scores, with scores 1-4 for the low naturalness group (n =21), score 5 for the medium naturalness group (n = 21) and scores 7-8 for the high naturalness group (n = 36). Participants in the urban street condition were excluded from these analyses because of the smaller range of their naturalness scores. We applied post-hoc comparisons to test for contrasts between the built vs. the natural settings, and pairwise differences among the conditions. To control for multiple testing, we adjusted the p-values of the pairwise comparisons using Šidák correction.

Keywords were classified by two researchers along the dimensions of valence (positive/negative) and arousal (high/low) using the circumplex model of affect (Russell, 1980). Occasional disagreements (< 5%) were discussed to reach a consensus. Nearly all keywords (95%) could be placed within one of the four affective categories of the model. Remaining keywords (which mostly consisted of comments on the quality of the presentation e.g. "well-filmed") were excluded from the analysis. Differences between conditions were assessed using Chi-square tests for independence of categorical data.

3. Results

3.1. Manipulation checks

3.1.1. Stress induction

The main effect of time (T1, T2) was significant for all three restoration measures, p-values < .05. Negative mood was significantly higher at T2 after the scary movie than during the baseline measurement at T1, mean change = 0.73, 95% CI = 0.53 to 0.91, $p < .001$. Vitality was generally lower after the scary movie than at baseline, mean change = -0.24, 95% CI = -0.41 to -.07, $p <$ .01. Restorative state was also lower after the scary movie than at baseline, mean change = -0.15, 95% CI = -0.28 to -0.01, $p < .05$. Responses to the stressor did not differ between the four conditions, all p-values > .35 (see Table 2 for the means per condition). The four conditions also did not differ significantly on any of the three dependent variables at baseline or after the scary movie, p-values >.75. Thus, the stress induction was successful for all three dependent measures.

3.1.2. Perceived naturalness

The four environments differed significantly in perceived naturalness, $F(3, 98) = 21.68$, $p <.001$, $\eta_p^2 = .4$. The urban street was rated significantly less natural ($M = 2.46$, $SD = 1.59$, range 1-5) than the parkland ($M = 4.89$, $SD = 1.15$, range 3-7), the tended woodland ($M = 4.88$, $SD = 1.39$, range 2-7) and the wild woods ($M = 5.96$, $SD = 1.46$, range 2-7), all corrected p-values < . 001. The wild woods were rated significantly more natural than the parkland and the tended woodland, corrected p-values < .05. These findings are largely consistent with our a-priori classification of the environments as ranging from built-up to very natural. However, contrary to our expectations, the tended woodland was not rated as more natural than the parkland, corrected p-value =1, and the large ranges indicate that there were substantial individual differences in perceived naturalness.

322

323 *3.2. Recovery from stress*

324 *3.2.1. Negative mood*

325 Negative mood generally decreased after viewing the environmental presentation, F (1, 97) =
326 17.81, $p < .001$, $\eta_p^2 = .16$, but the amount of decrease differed significantly across conditions, as
327 indicated by a significant interaction between time of measurement (T2, T3) and condition F (3,
328 97) = 2.77, $p < .05$, $\eta_p^2 = .08$. As shown by the unadjusted means in the upper part of Table 2 and
329 the covariate-adjusted means in Figure 2a, participants in the three natural conditions generally
330 showed stronger and more complete recovery (estimated mean change = -0.83, SE = 0.07) than
331 participants in the urban street condition (estimated mean change = -0.45, SE = 0.13). This
332 contrast in recovery between the built and the natural conditions was significant, estimated mean
333 difference = 0.38, 95% CI = 0.09 to 0.67, $p < .05$. The decrease in negative mood was only
334 significant in the parkland condition, $p < .001$, decreases in the other conditions did not reach
335 significance, p-values > .13. There was a significant pairwise difference in recovery between the
336 urban street and the urban park, corrected $p < .05$. None of the other pairwise comparisons
337 reached significance, corrected p-values > .27.

338

339 *3.2.2. Vitality*

340 Recovery of vitality differed marginally across conditions, F (3, 97) = 2.09, $p = .1$, $\eta_p^2 = .06$,
341 while the main effect of time was not significant, F (1, 97) = 0.05, $p > .82$. As shown in the
342 middle part of Table 2 and in Figure 2b, participants in the natural conditions generally showed
343 an increase in vitality (estimated mean change = 0.21, SE = 0.1) while participants in the urban
344 street condition showed a further decrease in vitality (estimated mean change = -0.28, SE =

345 0.19). This contrast in recovery between the built and the natural conditions was significant,
346 mean difference = 0.49, 95% CI = 0.07 to 0.91, $p < .05$. The decrease in vitality in the urban
347 street condition was significant, $p < .05$, but the increases in vitality in the natural conditions
348 were not significant, p-values > .16. None of the pairwise comparisons of recovery of vitality
349 among the four conditions reached significance, corrected p-values > .1.
350
351 *3.2.2. Restorative State*
352 Restorative state generally increased after viewing the environmental presentation, F (1, 97) =
353 23.54, $p < .001$, $\eta_p^2 = .2$, with the amount of increase differing significantly across conditions, F
354 (3, 97) = 3.64, $p < .05$, $\eta_p^2 = .1$. As shown in the lower part of Table 2 and in Figure 2c,
355 restorative state increased significantly to scores above baseline values in each of the three
356 natural conditions (estimated mean change = 0.67, $SE = 0.1$) while it remained approximately
357 constant in the urban street condition (estimated mean change = 0.03, $SE = 0.1$). This contrast in
358 recovery between the built and the natural conditions was significant, mean difference = 0.64,
359 95% CI = 0.23 to 1.05, $p < .01$. There were significant pairwise differences in recovery of
360 restorative state between the urban street and the parkland, and between the urban street and the
361 wild woods, corrected p-values <.05. None of the other pairwise comparisons reached
362 significance, corrected p-values > .35.
363
364 *3.2.3 Covariate effects*
365 Stress reactivity, as measured by the T1-T2 change scores, was significantly related to recovery
366 in negative mood, F (1, 97) = 61.41, $p < .001$, $\eta_p^2 = .39$, vitality, F (1, 97) = 11.31, $p < .01$, $\eta_p^2 =$

.1, and restorative state, F (1, 97) = 13.1, $p < .001$, $\eta_p^2 = .12$. In general, participants who reacted more negatively to the stressor, reacted more positively to the environmental presentation.

3.2.4 Influence of perceived naturalness

Perceived naturalness significantly affected recovery of vitality in the natural conditions, F (1, 72) = 3.92, $p < .05$, $\eta_p^2 = .1$. As shown in Figure 3, participants who perceived the green spaces as natural (score 5) or very natural (score 6 or 7) showed an increase in vitality (estimated mean change = 0.31 , SE = 0.11) while participants who perceived the green space as not so natural (score 4 or lower) showed a further decrease in vitality (estimated mean change = -0.25 , SE = 0.14). Although the increase in the high perceived naturalness group, and the decrease in the low perceived naturalness groups were not significant, p-values > .31, the contrast in recovery between the low and the two high perceived naturalness groups was significant, mean difference = 0.56; 95% CI = 0.21 to 0.92, $p < .01$. Perceived naturalness did not significantly affect recovery of negative mood and restorative state, p-values > .34.

3.3 Keyword analysis

As shown in Table 3, reactions to the urban street were predominantly negative (64%), while reactions to the parkland (80%), tended woodland (75%) and wild woods (77%) were predominantly positive. The difference in frequency of positive and negative keywords between the urban street and the three natural conditions was significant, Chi^2 (1) = 42.63, $p < .001$. Most of the negative reactions to the urban street reflected low arousal e.g. ‘boring’ and ‘uninteresting’. However, more high-arousal negative terms such as ‘claustrophobic’ and ‘confusing’ were also used.

All three natural settings were most commonly described with positive, low arousal terms such as 'calming', 'peaceful', and 'relaxing', underlining their high restorative potential. The wild woods were less often (65%) described with low arousal positive and negative keywords such as 'calming' and 'boring' than the other two more tended natural settings (85%), and this setting also attracted more high arousal positive and negative descriptors (35%) such as 'refreshing' and 'disorienting' than the tended natural settings (16%). This difference in frequencies of high and low arousal keywords between the wild woods and the other two natural settings was significant, Chi^2 (1) = 10.06, $p < .01$.

4. Discussion

The results of this study add to the mounting evidence for the greater restorative potential of urban green spaces relative to built urban spaces (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Van den Berg et al., 2007; Velarde et al., 2007). Using an experimental design, in which participants were first exposed to a scary movie and then randomly assigned to conditions of viewing natural and built urban spaces, we measured stronger recovery in negative mood, vitality and restorative state in the natural conditions as compared to the built urban street condition. Contrary to expectations, we did not find significant differences in recovery between the natural conditions, which included a parkland, a tended woodland and wild woods. These non-significant findings are noteworthy given that other experimental studies have also found few differences in restorative impacts between different types of natural settings (Beil & Hanes, 2013; Tyrväinen et al., 2014), except for studies comparing extreme – very dense and wild– natural settings (Gatersleben & Andrews, 2013; Martens et al., 2011). Thus, the lack of

differences in restorative impacts between three natural conditions could be a genuine phenomenon, perhaps reflecting the operation of a common (visual) trigger of restoration that is inherent to all natural stimuli and settings (see Joye & Van den Berg, 2011).

The null findings regarding the impacts of degree of naturalness may also have been driven by methodological issues. Although we took extensive precautions to standardize our presentations on all relevant dimensions except naturalness, there were some possible confounders, such as the presence of exotic plant species and a boundary wall in the tended woodland, which may have influenced the results. It is also possible that our measures were not sensitive enough to pick up more subtle nuances in restorative experiences. In particular, the analysis of keyword data suggests that our measures may have missed the more intense, high arousal positive and negative feelings that were reported by participants who viewed the wild woods. Alternatively, it is also possible that participants' personal impressions of their reactions to the setting do not provide accurate information as to their actual recovery.

Participants' reactivity to the stressor was found to be an effective covariate that eliminated part of the individual variance in recovery that was unrelated to the environmental conditions. This finding underlines the importance of selecting appropriate covariates when comparing restorative effects of different types of settings. The stronger recovery of participants who showed more stress reactivity may be partly explained by the mere fact that their post-stressor reactions created more potential, and perhaps also a greater need, for recovery. Additionally, individual differences in the degree to which people rely on external support to regulate their emotions may also have played a role (Koole, 2009).

Previous research has found positive relationships between perceptions of naturalness and self-reported likelihood of restoration and well-being (Dallimer et al., 2012; Fuller et al., 2007). However, to the extent of our knowledge, our study is the first to show that perceptions of naturalness are positively related to actual restoration as measured by changes in self-rated vitality, independent of the physical characteristics of settings. The causal direction of this relationship remains unclear. It is possible that people's conceptions of naturalness and attitudes toward nature influence their restorative nature experiences, as recently suggested by Wilkie and Stavridou (Wilkie & Stavridou, 2013). However, it is also possible that the experience of recovery from stress guided participants' perceptions of naturalness, or a third variable (e.g. optimism) could have influenced both recovery and perceived naturalness.

The focus on common types of green space makes our research very relevant to green space policy and practice. However, a limitation of our approach is that it does not provide insight into the contributions of specific physical dimensions like enclosure and tendedness. Because we did not vary the presence of acoustic information, it is also not possible to make inferences about the contributions of sound to the restorative capacity of the environments. The use of a student sample was also an important limitation of the study, because their responses may not be representative for the general population. A further limitation is that we used only self-report measures, we did not measure physiological reactions or other more objective measures of restoration. The short length of exposure in combination with the use of photos and videos may have compromised the applicability of our results to real-life experiences. The restriction to urban spaces in Sheffield in the month of June may limit the generalizability of the results to

459 other geographical regions and seasons. We did not measure participants' familiarity with the
460 settings, and thus were unable to control for possible influences of this variable.
461
462 By selecting more extreme (e.g. very wild or very dense) urban green space settings future
463 research may enhance the chances of finding significant differences among natural conditions.
464 At the same time, however, such an approach is less relevant to the everyday practice of green
465 space management and design and could even provide misleading information. For example, the
466 finding that very dense and unstructured natural settings can hamper restoration (Gatersleben &
467 Andrews, 2013) may lead managers and decision-makers to ban all wild nature from urban areas,
468 while our research suggests that moderate types of 'urban wilderness' can promote levels of
469 restoration comparable with more tended types of green space, and may stimulate feelings of
470 excitement and refreshment.
471
472 Future experiments could also manipulate other theoretically relevant physical characteristics
473 such as variations in topography or the presence of water (Ulrich, 1983), and additional variables
474 like sounds (Alvarsson, Wiens, & Nilsson, 2010), the presence of others (Staats & Hartig, 2004),
475 or medium of presentation (Kahn et al., 2008). The range of environments could be extended to
476 include different types of built settings or mixed scene types with urban and green elements (e.g.
477 pocket parks or green rooftops and walls) (Peschardt & Stigsdotter, 2013; Tenngart Ivarsson &
478 Hagerhall, 2008). More insight into the cumulative effects of long term exposure to actual green
479 space in the living environment is also warranted (Bowler et al., 2010). To identify sources of
480 individual variability in stress reactivity and recovery, future research needs to consider
481 individual difference variables such as emotion regulation style (Koole, 2009). The validity and

reliability of our self-developed restorative state scale needs further testing in future studies, preferably in relation to physiological and attentional outcomes. To avoid publication bias it is important that non-significant findings are published.

To learn more about the causal direction of the relationship between perceived naturalness and recovery of vitality, future research could measure perceptions of naturalness in advance of the experimental treatment, e.g. by means of a photo perception study (see Wilkie & Stavridou, 2013). Future research could also explore whether recovery rates vary with known predictors of individual differences in perceived naturalness like socio-economic status, age and personality characteristics (Jorgensen & Tylecote, 2007; Van den Berg & Van Winsum-Westra, 2010).

Overall this study has made some important first steps to obtaining a more nuanced picture of restorative experiences in urban public spaces that goes beyond the natural versus built dichotomy. Most importantly, the findings suggest that the relationship between naturalness and restorativeness may not be as strong and straightforward as is often assumed. Besides physical characteristics like naturalness, individual perceptions and needs should also be taken into account when designing urban green spaces. Nevertheless, the question of whether 'setting type matters' still remains one of the more outstanding problems in restorative environments research and much remains to be learned about how to create optimally restorative urban built and green spaces.

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List of tables

Tables with captions (one per page)

Table 1.

Items in the Restorative State Scale.

Restorative state Scale
1. My mind is not invaded by stressful thoughts
2. I can take time out from a busy life
3. I can lose all sense of time
4. I am thinking about everything and nothing at the same time
5. I can make space to think about my problems
6. I can leave all my problems behind me
7. My mind just wanders in infinity
8. I can imagine myself as part of the larger cyclical process of living
9. I feel connected to the natural world

Table 2.

Unadjusted means and standard deviations for outcome measures by condition and time of measurement

	T1 Baseline	T2 Post-stress	T3 Post-environment
Negative mood (1-7)			
Street	1.71 (0.55)	2.66 (1.03)	2.09 (0.84)
Parkland	1.84 (0.47)	2.33 (0.79)	1.51 (0.52)
Tended Woodland	1.89 (0.54)	2.68 (1.03)	1.92 (0.94)
Wild woods	1.82 (0.59)	2.55 (1.05)	1.75 (0.75)
Vitality (1-7)			
Street	4.02 (1.04)	3.89 (1.01)	3.56 (1.06)
Parkland	3.92 (0.99)	3.65 (0.64)	3.75 (1.03)
Tended Woodland	4.08 (1.08)	3.8 (0.92)	4.02 (0.94)
Wild woods	3.99 (1.06)	3.73 (0.98)	4.08 (1.0)
Restorative State (1-7)			
Street	3.84 (0.84)	3.57 (0.91)	3.66 (1.0)
Parkland	3.58 (0.82)	3.47 (0.76)	4.21 (0.94)
Tended Woodland	3.75 (0.88)	3.63 (0.85)	4.11 (0.7)
Wild woods	3.56 (0.97)	3.45 (1.12)	4.18 (1.28)

Table 3.

Distribution of keywords in the four environmental conditions across valence and arousal categories, with examples of frequently used words

	Positive		Negative		
	High arousal	Low arousal	High arousal	Low arousal	*Total*
Urban Street	12%	24%	21%	43%	100%
Example words	curious, lively, explorative	calming, restful, leisurely	claustrophobic angry, confusing	boring, dull, uninteresting	
Parkland	12%	68%	0%	20%	100%
Example words	bright, healthy, happy	calming, serene peaceful	-	boring, tired, vulnerable	
Tended Woodland	15%	60%	5%	20%	100%
Example words	free, fresh, breathtaking	calming, peaceful, relaxing	nervous, scary, unable to concentrate	boring, lonely, isolated	
Wild Woods	23%	54%	12%	11%	100%
Example words	free, refreshing exciting	calming, peaceful, quiet	anxious, tense, disorienting	alone, boring, sleepy	

List of figures

Figure 1

Figure 2

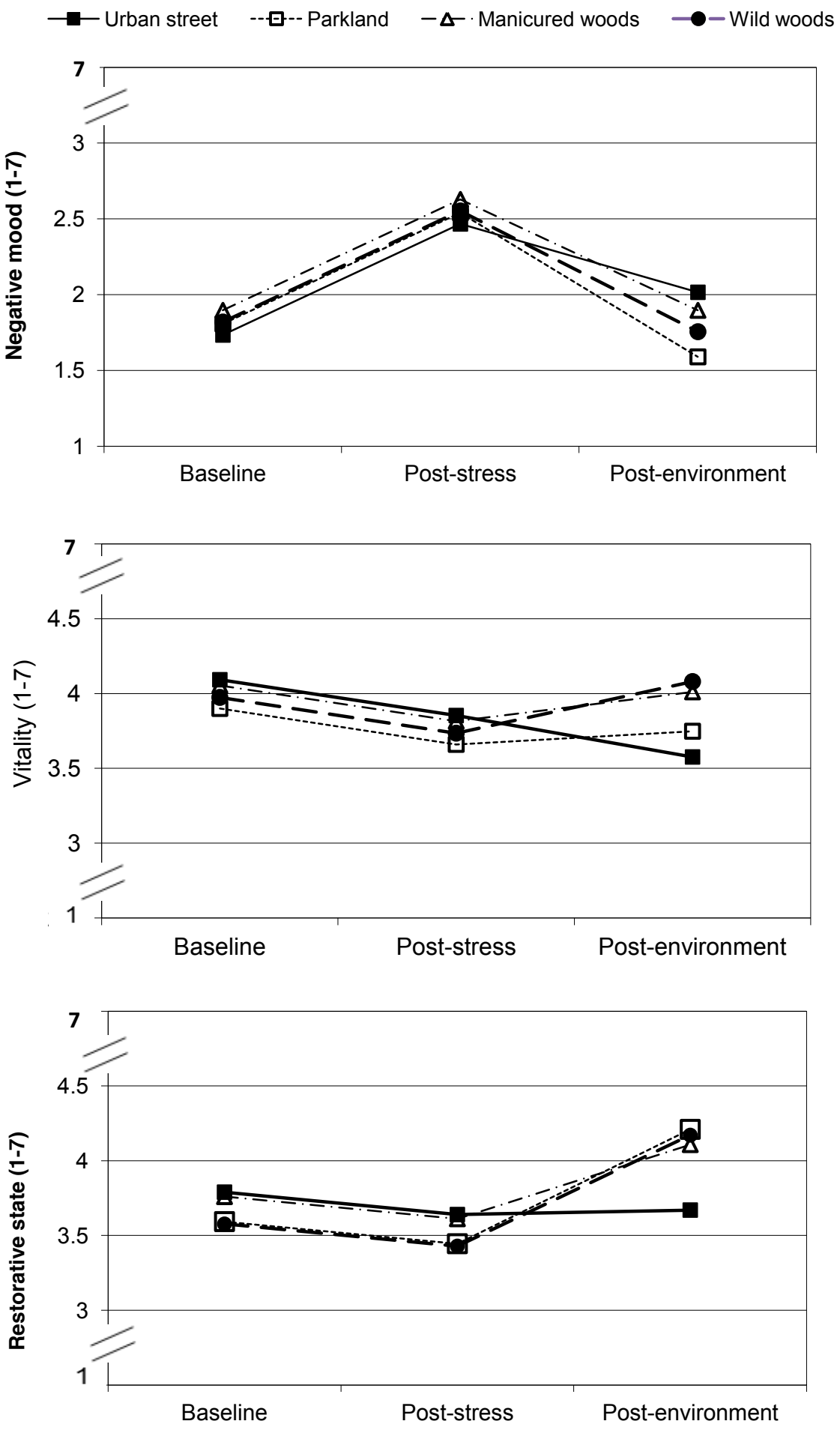
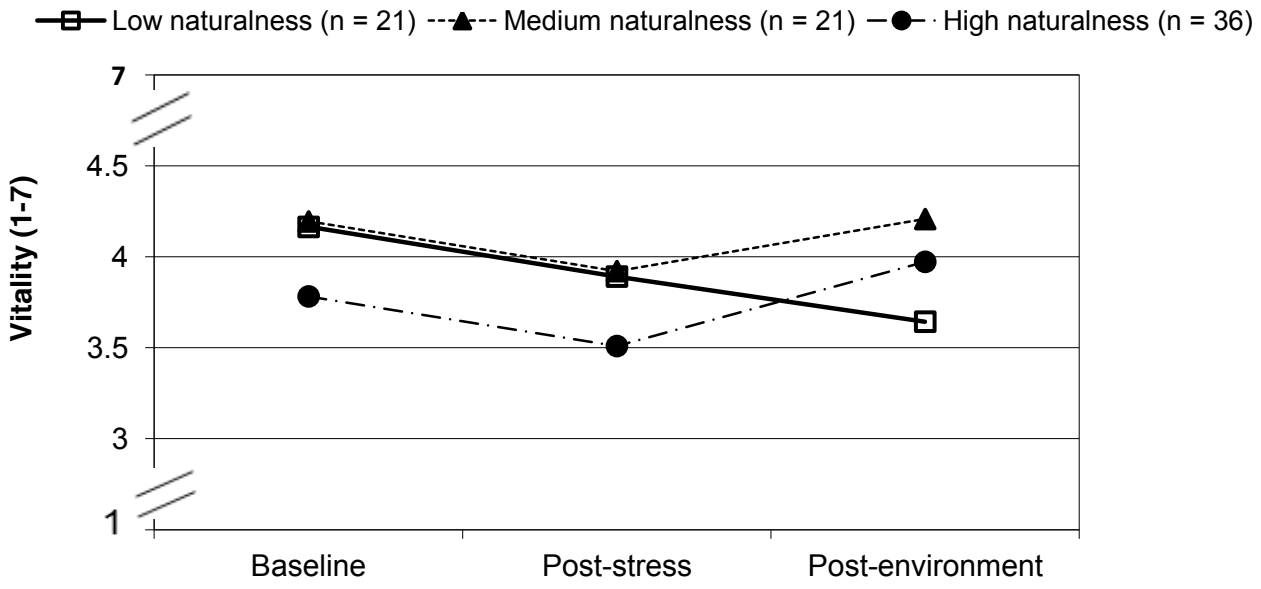

Urban street
Parkland
Manicured woods
Wild woods
Negative mood (1-7)
7
3
2.5
2
1.5
1
Baseline
Post-stress
Post-environment
Vitality (1-7)
7
4.5
4
3.5
3
1
Baseline
Post-stress
Post-environment
Restorative state (1-7)
7
4.5
4
3.5
3
1
Baseline
Post-stress
Post-environment

Figure 3


Low naturalness (n = 21)
Medium naturalness (n = 21)
High naturalness (n = 36)
Vitality (1-7)
7
4.5
4
3.5
3
1
Baseline
Post-stress
Post-environment

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Dr Anna Jorgensen is a Senior Lecturer in the Department of Landscape at the University of Sheffield UK. She is the editor of the Routledge book Urban Wildscapes, and the Managing Editor designate. Her research deals with the human benefits and social significance of urban green space, with a particular interest in wilderness-like and biodiverse urban settings.

Edward (Ted) Wilson is a silviculturist and forest scientist with an interest in the sustainable management and conservation of forest resources. He has worked in both Europe and North America, and held a variety of academic and professional appointments, including Assistant Professor at the Faculty of Forestry, University of Toronto and Senior Lecturer at the National School of Forestry (England).