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Effects of urban street vegetation on judgments of restoration likelihood

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ABSTRACT

Knowledge of how to increase the restorative quality of residential streetscapes may help to offset problems entailed by urban densification. The present study considered the effects of trees, grass, and flower beds on ratings of restoration likelihood for streetscapes. We used digital-imaging techniques to systematically vary these natural elements in images of residential streets with different architectural characteristics. Using a web-based procedure, 103 images were rated by independent groups of Icelandic adults ($N = 188$) on either restoration likelihood, preference, being away, or fascination. Group mean scores on the psychological variables were calculated for each image, and the images were then used as the units of analysis in regression analyses. Ratings of restoration likelihood increased with increase in the number of street trees and the presence of flower beds. These effects were apparently mediated by perceptions of being away and fascination. The architectural characteristics of buildings along the streets had a strong independent effect on restoration likelihood ratings, but they did not moderate the positive effects of vegetation on restoration likelihood ratings. The results provide guidance for the design of more psychologically sustainable urban residential environments.

Introduction

Streets take up some 25–35% of all developed urban land (Jacobs, 1997). This is a substantially higher proportion of urban area than that dedicated to parks and other public spaces. Due to their role in the urban infrastructure and their proximity to residences, streets are among the places where residents spend much of their time outdoors (Getz et al., 1982). Streetscapes also occupy the views that many people have from inside their homes and workplaces. Given the normal, recurring needs for psychological restoration experienced by people in cities, knowledge of how to increase the restorative quality of urban streetscapes should be beneficial, both for the people living and working beside them and also for those who are moving along them as they travel to some destination. To address the need for such knowledge, in the present study we use a large number of computer-generated images to estimate the effect of different types and amounts of vegetation on judgments of the likelihood of restoration in urban streetscapes.

Restorative quality in environments

Psychological restoration is a key pathway through which urban nature promotes public health (e.g., Health Council of the Netherlands, 2004; Hartig et al., 2014). Attention restoration theory (ART) (Kaplan and Kaplan, 1989; Kaplan, 1995) provides an approach to understanding how natural elements on the streetscape level might serve psychological restoration. The theory is concerned with a capacity to direct attention, a cognitive resource assumed to be necessary for effective functioning in contemporary urban societies. People commonly rely on this resource in daily life, as when performing paid work, finding their way around town, and monitoring the behavior of other people as they go along. Directing attention involves inhibiting other, more appealing or interesting stimuli, and this is assumed to require effort. Because it requires effort, ART further assumes that this inhibitory mechanism can become fatigued. Attentional fatigue can become apparent in ineffective work performance, failure to pick up important cues on appropriate action, and increased irritability, among other behaviors. A chronic lack of restoration will entail negative consequences for effective functioning, well-being, and health (Hartig et al., 2011).

To mitigate attentional fatigue, ART emphasizes the benefits of environmental experiences characterized by high levels of four qualities (Kaplan and Kaplan, 1989). *Being away* refers to

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psychological distancing from the routines and mental contents that ordinarily take up directed attention. *Fascination* refers to an effortless form of attention evoked by the environment. *Extent* refers to the degree of order and coherence in the environment as well as to the scope for involvement; one must have enough to perceive, think about and experience to remain engaged in the environment, and enough order to do so without becoming lost or disoriented. *Compatibility* refers to the degree to which the environment supports one's purposes and inclinations. Kaplan and Kaplan argue that features of natural environments engender these four experiential qualities to a relatively high degree, but they also acknowledge that built features of environments can support restorative experiences. The four restorative qualities are in any case thought to work as mediators between diverse physical environmental attributes and restoration; that is, features of the physical environment can affect the level of each quality as experienced by a person, which in turn can affect the degree of restoration realized by that person.

In the present study, only being away and fascination are under consideration, in line with the approach taken in the research on which this study builds (e.g., Nordh et al., 2009). We expect ratings of being away and fascination to be affected positively by the natural elements in the streetscape images and in turn to positively influence ratings of the likelihood of restoration in the depicted settings.

Selection of natural elements

Although much research attention has been paid to restorative values of urban green spaces, relatively few studies have considered the potential restorative benefits of vegetation along urban streets (e.g., Jiang et al., 2014; van Dillen et al., 2012; Mitchell et al., 2011). However, numerous studies have shown that trees and other vegetation affect preferences for urban environments (e.g., Stamps, 1997; Wolf, 2009), and several empirical studies have found that effects of environmental variations on preferences can be mediated by psychological restoration or expectations of restoration (e.g., van den Berg et al., 2003; Staats et al., 2003; Hartig and Staats, 2006). It follows that, where evidence concerning restorative benefits is lacking, one can turn to the literature on environmental preferences for help in identifying promising approaches to restorative urban design that make use of vegetation.

In the following, we consider three kinds of vegetation – trees, grass and flowers – that research has found to be related with preferences and/or with expectations about restoration with regard to urban streets.

Trees

Trees in the urban environment are seen as bringing nature closer to urban residents (Schroeder et al., 2006), and it appears that many people think that trees in urban areas contribute significantly to their quality of life (Lohr et al., 2004). Regarding possibilities for restoration, Lohr et al. (2004) reported that the potential to help people to feel calmer was ranked second highest among the benefits of trees in urban settings in the USA. Studies have found that streetscapes with trees are ordinarily more preferred than streetscapes without trees (Sommer et al., 1990; Stamps, 1997; Gorman, 2004; Wolf, 2009), and having trees along streets may be just as important for residents as having them in parks (Getz et al., 1982). In a streetscape, trees may be the strongest single factor influencing preference when compared to other natural elements such as hedges, flowers, grass and soil (Todorova et al., 2004).

Several attributes of street trees may play a role in evaluations of streetscapes and at the same time have significant practical implications. Some attributes depend on the tree species. Particular species of street trees can be more or less preferred depending on their shape and other visual attributes, with deciduous trees generally preferred over coniferous trees (e.g., Summit and Sommer, 1999). Different species are also more or less demanding in terms of nuisances and maintenance requirements (Tomalak et al., 2011).

Species aside, the size and number of trees along a street will together affect the amount of apparent greenery in a streetscape. In light of the large body of evidence concerning the positive relationship between naturalness and both perceived restorativeness (e.g., Hartig et al., 1997a; Laumann et al., 2001) and preferences (e.g., Kaplan and Kaplan, 1989; Hartig, 1993; Stamps, 1999), more apparent greenery could be expected to positively affect evaluations of streetscapes. Also, Kalmbach and Kielbaso (1979) found that a majority of residents in their sample wanted more trees in their own residential streets, and the desire for more trees was stronger among those who presently had relatively few trees. They also found some evidence, however, that preference may decline after the amount of tree greenery exceeds a certain point (cf. Wolf, 2003).

Some trees may obscure others when viewed from a given vantage point (cf. Schroeder and Orland, 1994), and this might affect their impacts on evaluations. It follows that the amount of apparent greenery that a given number of trees contributes to a streetscape also depends on their arrangement. For example, for a person looking down a street, a given number of trees evenly distributed along both sides could present an objectively larger amount of visible greenery than if the same number of trees were all aligned along one side, with trees in the foreground largely obscuring those behind them. Moreover, the amount of greenery aside, people may appreciate the greater symmetry that would obtain with trees aligned along both sides of a street. Enquist and Arak (1994) claim that symmetrical patterns hold an almost universal appeal for humans. In line with this claim, Weber et al. (2008) assert that preference ratings can be increased if vegetation along streetscapes is symmetrical, with similar height and type along both sides.

In light of the foregoing discussion, we expect the size and number of street trees will correlate positively with both rated restoration likelihood and preference, at least at the lower end of the distributions for those physical attributes,. Furthermore, we expect that streetscapes with trees arranged symmetrically along both sides will be considered as more restorative and will be preferred more than streetscapes with trees along only one side.

Understory vegetation: Flowers and grass

Little research has addressed the impact of understory vegetation in streetscapes on either restoration likelihood or preference. There is however some evidence concerning flowers and grass. Todorova et al. (2004) found that flowers were more preferred as elements for street-side plots than bare soil, grass or hedges. They even found greater preference for streets that lacked trees but had flowers arranged in long plots along the curb in comparison to streets with trees and bare soil, grass or hedges arranged beneath them along the curb. Preference was highest for plantings with bright, low flowers orderly arranged in the space beneath the trees (cf. Wolf, 2004). Todorova et al. furthermore found that streets with flowers were rated as relatively restful.

With regard to grass, Todorova et al. (2004) found that streets with grass plots were more preferred than streets without grass plots. They did not however report results concerning whether grass also made the streets appear more restful or otherwise psychologically beneficial.

In light of these preference findings and previous findings concerning the relationship between preference and restorative potential, we nonetheless expect the presence of flowers and the presence of grass to each increase judged restoration likelihood as well as preference.

A potential interaction between vegetation and architectural characteristics

The amounts of trees, grass and flowers are not the only physical attributes of an urban streetscape that may affect ratings of restoration likelihood and preference. The buildings along the street may also have a significant effect. In the forerunner to this study, Lindal and Hartig (2013) analyzed mean ratings of restoration likelihood for images of 145 urban streetscapes that did not include any trees or other street-side vegetation, but which were lined by buildings that had varying architectural characteristics. They found that the roofline silhouette, façade details, and the height of the buildings all affected judgments of restorative potential. The streetscapes judged to have low restorative potential were lined by three-story buildings with little visual complexity, whereas the streetscapes with the highest mean ratings of restoration likelihood were lined by one-story buildings with relatively high levels of visual complexity. Note however that the mean restoration likelihood ratings for the latter streetscapes were not high in some absolute sense; they fell close to the mid-point of the scale used.

The question arises whether the impact of vegetation on the restorative potential of a streetscape depends on the architectural attributes of the buildings along the street. For example, street vegetation may increase or decrease evaluations of the complexity of the built urban environment, as they can break up a monotonous environment or mask a chaotic one (Thayer and Atwood, 1978; Smardon, 1988; Wolf, 2003). Trees and other vegetation may also modify the sense of enclosure otherwise provided by buildings through the ways in which they define spaces both vertically and horizontally (cf. Ewing et al., 2006; Bell et al., 2005).

Building on the results from Lindal and Hartig (2013), we chose for use in the present study those of their streetscape images that had the most divergent ratings of restorative potential on the basis of their architectural attributes alone. It is an open question whether the addition of any of the street vegetation variables as well as the overall amount of street vegetation will increase ratings of restoration likelihood and preference to a greater degree in the streetscapes with architectural attributes that had previously elicited low ratings of restorative potential.

The present study

The primary objective of the present study is to generate knowledge about the use of trees and other vegetation in increasing the restorative quality of urban streetscapes. Working from available literature on restorative environments and environmental preferences, we formed expectations regarding positive effects on restorative quality due to the number of trees, the size of the trees, the arrangement of the trees along the street, the presence versus absence of grass, and the presence versus absence of flowers. Accordingly, the analyses of primary interest address expectations that judgments of restoration likelihood increase with (a) increases in the number of street trees; (b) increases in the size of street trees; (c) the presence of street trees on both versus only one side of the street; (d) the presence of grass; and (e) the presence of flowers. This set of analyses also addresses expectations that the positive effects of the natural elements on restoration likelihood judgments are at least partially mediated by ratings of being away and/or fascination.

A secondary objective of the present study is to examine how streetscape vegetation interacts with the architectural characteristics of the buildings that line the street in affecting restoration likelihood judgments. In a final set of analyses we therefore consider whether any of the street vegetation variables or the overall amount of vegetation have a greater positive impact on ratings of restoration likelihood for streetscapes that previously elicited low ratings of restorative potential because of their architectural attributes.

Method

Visual stimuli

The architectural backdrop in the streetscapes

This study involved computer-generated images of urban residential streetscapes that were based on images used by Lindal and Hartig (2013). The streetscapes in their study varied in architectural characteristics alone; they did not include any greenery. The streetscapes from that study with the two lowest and the two highest mean values for judgments of restoration likelihood were used as platforms for the further manipulations of the environment in terms of greenery. The two images with the lowest values both had a mean of 2.35, and the two images with the highest values both had a mean of 5.14 on the 0–10 scale used for ratings of restoration likelihood. Thus, the streetscapes previously rated low in restorative potential had a mean that was low on the scale in an absolute sense, whereas the streetscapes with the highest ratings were only around the mid-point of the scale used, and so were not considered high in restorative potential in some absolute sense.

All of the streetscapes had a uniform set of spatial criteria, with a block of buildings on each side of the street[1], and buildings along the far side of the distal cross street to close off the space. In the streetscapes previously judged to have relatively higher restorative potential, the blocks had one-story buildings on sunken cellars, nearly all of which had façade details as well as diversity in the skyline silhouettes. In the two streetscapes previously judged to have low restorative potential, the blocks consisted of buildings three stories high on sunken cellars, with no facade details and relatively simple and uniform skyline silhouettes. Street lamps and traffic signs were included in all streetscapes, but cars, people and animals were excluded.

The street vegetation

Although we recognize that the choice of street tree species is an important practical consideration for arborists and urban foresters, in this study we decided to hold constant the type of tree. A three-dimensional unspecified deciduous tree was downloaded from the Google 3D Warehouse website. The density of the canopy was increased and other minor adjustments were made before adding a tree to the streetscape. The trees were introduced according to a scheme in which their number, arrangement and size were systematically manipulated. The number of trees had four levels: 0, 2, 4 or 6 trees. We did not include more than six trees due to technical restrictions. The intended number of trees in a streetscape was reached by copying the initial tree and then rotating it to prevent an identical appearance. The tree arrangement was on two levels: either all trees were on one side of the street, or half of them were on each side. In all cases, the trees were positioned at 30.5 cm from the pavement curb. The location of the trees along the street varied with the number of trees. When two trees were placed on one side, the pavement length was divided into tertiles and the trees were positioned at the tertile junctions. This was done to avoid the appearance of a large tree at the proximal end and one very small tree on the distal end with no vegetation in the middle. When two trees were divided across the two sides, the one tree on each side was positioned halfway down the street. When there were more than two trees on each side (i.e., when six trees were distributed on both sides, and when four and six trees were positioned

[1] The street and sidewalk widths conform to published standards for residential blocks (e.g., Ewing, 1994).

on one side), none of the trees was placed close to the curb of the cross-street at an intersection [in line with recommendations in the planning literature; e.g. Portland Parks and Recreation City Nature Urban Forestry, no date; Texas Chapter of the International Society of Arboriculture, no date]. Within the space remaining along the street, the trees were evenly distributed depending on the number of trees.

Tree size had two levels: small and medium. Urban trees from 6.1 to 9.0 m in height can be considered small, and trees from 9.1 to 12.2 m can be considered medium high (Grey and Deneke, 1978). In the study, small trees were 6.1 m and medium trees were 9.1 m. The volume of the medium tree was greater than that for the smaller tree, but the volume ratio for small to medium trees was not the same as the height ratio, given concerns about preserving a view down the street with medium trees. All of the trees in a given streetscape had the same size. A focus on small and medium size trees is consistent with the relative ease of introducing them into a streetscape; however, we recognize that the additional benefits provided by large trees could justify the greater costs associated with planting them.

In addition to varying numbers, sizes and locations of trees, the streetscapes were presented with grass or pavement covering the intermediate space framed by the walls of the buildings, the sidewalks and the door steps. The intermediate space was elevated 15 cm above the public sidewalks to give a sense of a semi-private space belonging to the residents. Both pavement and grass were created in Google Sketchup 7 (free version) by applying real life images of turf grass or pavement as a texture to the intermediate spaces.

Finally, the streetscapes were presented with or without beds of flowers. A model of unspecified flowers was downloaded from the Google 3D Warehouse website. All of the flowers had identical form and were low-lying, but they varied in color (yellow, orange, red, blue and purple). Beds of flowers were then created by multiplying the initial flower model and, to prevent a uniform appearance, rotating some of them. Due to technical restrictions, creating flowerbeds beneath the trees (cf. Todorova et al., 2004) was not possible. They were therefore arranged in relatively narrow plots in the intermediate spaces beside the doorsteps and near the wall of each building. In streetscapes without flowerbeds, the same area was occupied by grass or pavement.

Creation of the image pool

The manipulations of the street vegetation and other image features resulted in an image pool of 104 virtual streetscapes. The pool included one image with each possible combination of architecturally determined restorative quality (one of the two low restorative quality streetscapes or one of the two higher restorative quality streetscapes), number of trees when trees were present (2, 4 or 6), arrangement of those trees (one or both sides), size of those trees (small or large), and the presence of grass or pavement with/without flowers. In addition to these 96 images, the pool included eight images that had no trees but which had pavement or grass with/without flowers against one or the other architectural background.

The images were created and elaborated using Google Sketchup 7. All of the images had the same cloudless, blue sky which that program offers as a default, and the same lighting features. The date and time of day for the images were set for June 21 at 12:00 AM (i.e., the summer solstice in the northern hemisphere) to minimize shadow-projection from buildings and trees. Additional details of the spatial dimensions of the streetscapes, image capture, camera settings and rendering process are provided by Lindal and Hartig (2013).

Amount of vegetation

A quantification of the vegetation was done to support the test of the interactive effect of street vegetation and architectural characteristics. Following an approach described by Nordh et al. (2009), a grid of 588 cells was laid over any image that included vegetation. Each cell more than 50% covered by vegetation was marked, and then all marked cells were counted. The percentage of vegetation ranged from 0 to 25.9% of the cells across images.

Psychological variables

Independent groups of participants rated each of the streetscapes on either preference (*I like this environment*), judged likelihood of restoration (*I would be able to rest and recover my ability to focus in this environment*), being away (two statements combined into one item, *Spending time here gives me a break from my day-to-day routine; It is a place to get away from the things that usually demand my attention*), or fascination (two statements combined into one item, *This place is fascinating; My attention is drawn to many interesting things*). Ratings on these items were given with the same 11-point scale (0 = *not at all*, 10 = *completely*). The items for being away and fascination were taken from the Perceived Restorativeness Scale (PRS) (Hartig et al., 1997a,b).

Procedure

Data collection was carried out via the internet with the support of the Social Science Research Institute (SSRI) of the University of Iceland. The SSRI maintains an Internet Panel that consists of Icelandic residents aged 18 years and older who have agreed to participate in SSRI's online surveys. Panel members are recruited by telephone interviews with residents randomly sampled from the Icelandic National Register. Samples subsequently drawn from the panel for specific studies like this one can be considered representative of the population.

A random sample of 970 persons was drawn from the SSRI's Internet Panel for this study. The SSRI sent each person a request for participation together with a link to a website where the participants could access the study. The purpose of the study and other necessary information (e.g., regarding informed consent) were presented at the website, along with a link to start running the study. When started, each participant was presented with one of two different sets of streetscape images, each of which included half of the images. Each participant was asked to rate the images on only one of the psychological variables. The order of the images in the given set had previously been randomly generated using an online randomization program. The order was then fixed, and the participants went through the images from either first to last or vice versa. The participant was also asked to provide background information (age, gender, nationality and familiarity with the kind of environments shown in the images).

Participants who were to rate the images on one of the three variables related to restorative experience (i.e., being away, fascination, restoration likelihood) received the following scenario before they began the rating task, and they were asked to keep it in mind when rating the images: "*Imagine that it is afternoon and you are walking alone from work to home. You are mentally tired from intense concentration at work and you appreciate having a chance to stroll and recover before you have to go home to solve various matters.*" The scenario was meant to provide a standardized, plausible and relevant context for the rating task (cf. Herzog et al., 1997; Lindal and Hartig, 2013; Nordh et al., 2009, 2011; Staats et al., 2003). No scenario was presented prior to the ratings of preference.

Participants

In total, 188 Icelanders (57% women), ranging in age from 20 to 70 years ($M = 44.6$, $SD = 13.1$) participated in the study (response rate 19.4%). Our respondents' mean age corresponds fairly well with the mean age for the total population (42.9 years), but the proportion of women in our sample is higher than that in the total population between 20 and 70 (49.5%). As in the forerunner of this study (Lindal and Hartig, 2013), in which the participants were also Icelandic, the level of familiarity with streetscapes like those presented was generally low among the participants ($M = 3.97$ out of 11, $SD = 2.58$). Urban environments in Iceland are generally different from those presented in this study. Participants would therefore have little opportunity to regularly experience streetscapes like those shown in the study. Some participants would however have experienced similar environments when traveling or through different types of media presentations. Despite the generally low level of familiarity, we collected data only from Icelanders in this study to better relate the results to the results from the previous study, and because densification of urban areas in Iceland may in the near future involve streetscapes like those shown here.

Statistical analysis

Each participant rated only half of the images and then only on one of the four psychological variables. Thus, each participant was only asked to make 52 ratings in total. The number of participants rating a given variable ranged from 41 to 52. The number varied because the variable to be rated was assigned at random by the data collection program. Based on the ratings from a given group, a mean value was calculated for each image and then the mean values for the images were used for further analysis. Thus, our analyses did not treat the individual participants as cases or units of analysis, but instead treated the images as units of analysis. A mistake made during the online survey creation forced us to drop one streetscape, leaving 103 images for further analyses.

We completed three sets of multivariate analyses. The primary set of analyses assessed the strength of the independent direct effects of number, location and size of trees and the presence of flowers and grass on the judged likelihood of restoration. We also estimated mediation of the relationship between environmental features and restoration likelihood by being away and fascination. For these analyses, we used Preacher and Hayes' (2008) regression-based approach, in which the total and the direct effect of the independent variables on the dependent variable (c and c') and the indirect effect though mediators (ab) can be tested simultaneously using confidence intervals obtained with bootstrap methods. The mean ratings of being away (provided by one group) correlated strongly ($r = .90$) with the mean ratings of fascination (provided by another group); we therefore tested separate regression models with either being away or fascination as the sole mediator to avoid collinearity.

The second set of multivariate analyses were the same as those in the first set, but with preference instead of restoration likelihood as the dependent variable. As in the first set of analyses, we did not include the variable representing the architectural characteristics of the buildings in the streetscapes, The third set of multivariate analyses assessed the interactive effect of architectural characteristics and street-side vegetation. We first performed a multiple regression analysis which included three variables: the overall amount of vegetation in the image, the composite architectural characteristics of the buildings lining the street (i.e., one-story buildings with moderate surface and silhouette complexity versus three-story buildings with low surface and silhouette complexity), and the interaction term. The vegetation variable was centered prior to creating the interaction term to avoid collinearity (Tabachnick and Fidell, 2007). Following up on this analysis, we performed five two-way analyses of variance (ANOVA). Each ANOVA crossed the composite architectural characteristics with one of the five vegetation variables (i.e., number of trees, arrangement of trees, size of trees, presence of flowers, presence of grass).

Results

Effects of the physical attributes on restoration likelihood ratings

The mean values for restoration likelihood ranged from low-to-moderate across the streetscapes (see Table 1). Those streetscapes that received the lowest, closest-to-average and highest ratings on restoration likelihood are shown in Fig. 1. Bivariate correlations show that, in keeping with expectations, restoration likelihood tended to be rated higher for streetscapes with more trees and with flowers present (see Table 1). Tree size, tree arrangement and the presence of grass also correlated positively with restoration likelihood; however, these correlations were not statistically significant.

Table 1
Descriptive statistics and correlation matrix for the variables in the analyses, based on 103 streetscape images.

	M	*SD*	Min	Max	1	2	3	4
Being away	4.02	.83	1.70	5.48	1			
Fascination	3.75	.85	1.64	5.63	.90[**]	1		
Restoration likelihood	4.29	.86	2.43	6.74	.66[**]	79[**]	1	
Preference	3.95	.76	2.04	5.75	.87[**]	.83[**]	.76[**]	1
Architectural properties[a]					.49[**]	.65[**]	.75[**]	.63[**]
Number of trees					.51[**]	.36[**]	.32[**]	.42[**]
Tree size[b]					.24[*]	.18	.08	.18
Tree arrangement[c]					.33[**]	.34[**]	.19	.27[**]
Grass[d]					.15	.12	.10	.17
Flowers[d]					.42[**]	.39[**]	.32[**]	.44[**]

Note: Pearson correlations. The psychological variables (being away, fascination, restoration likelihood, preference) were all measured on a scale from 0 to 10, on which low values correspond to less positive evaluations. Descriptive statistics for and correlations among the physical attributes are not reported as these were manipulated in the creation of the images rather than rated by study participants. By design they are not correlated.

[*] $p < .05$.

[**] $p < .01$

[a] Three stories and low complexity (=0) versus one story and moderate complexity (=1); a higher value indicates higher restorative potential as determined in a previous study.

[b] 0 = small trees, 1 = large trees.

[c] 0 = trees on one side, 1 = trees on both sides.

[d] 0 = not present, 1 = present.

Fig. 1. Streetscape images with the highest, lowest and closest to average likelihood of restoration ratings, calculated looking across the participants who provided the ratings. (From left to right) The streetscape image with lowest mean rating for restoration likelihood (*M* = 2.43, *SD* = 2.19), the streetscape image with the closest-to-average mean rating for restoration likelihood (*M* = 4.24, *SD* = 1.74) and the streetscape image with highest mean rating for restoration likelihood (*M* = 6.74, *SD* = 2.51).

Fascination and being away as mediators

The rated mean values for being away and fascination were relatively low (see Table 1). Both being away and fascination showed strong, positive bivariate correlations with multiple physical attributes as well as with restoration likelihood (see Table 1), in keeping with the expectation that they would mediate relationships between physical attributes and judgments of restoration likelihood.

Table 2
Indirect effects of the association between the environmental components and restoration likelihood, through being away.

	Point estimate	BC 95% confidence interval*	
		Lower	Higher
Number of trees	.27	.15	.40
Tree size	.01	−.14	.17
Tree arrangement	.15	−.01	.31
Presence of grass	.17	.01	.33
Presence of flowers	.47	.28	.70

Note: N = 103 streetscape images.
* BC (bias corrected confidence interval) based on bootstrapped estimates. When the confidence interval does not include zero, the indirect effect can be regarded as statistically significant at $p < .05$.

In the regression analysis with being away as a mediator, the environmental components accounted for 44.9% of the variance in restoration likelihood. When adjusting for the influences of the other environmental components, the total effects (c) of number of trees and presence of flowers were statistically significant (see Fig. 2 and Table 2). When being away was added to the model, the indirect effects of number of trees, presence of grass and presence of flowers were significant. No direct effects (c') of the environmental components remained significant with being away as the mediator. Neither tree size nor tree arrangement significantly affected ratings of being away.

With fascination as a mediator, the environmental components accounted for 63.1% of the variance in restoration likelihood. When adjusting for the other environmental components, the total effects (c) of number of trees and presence of flowers were significant (see Fig. 3 and Table 3). When added to the model, fascination mediated the effects of number of trees, tree arrangement, and presence of flowers on restoration likelihood. As with being away, no direct effects (c') of the vegetation variables remained significant with fascination as the mediator in the model. Neither tree size nor the presence of grass affected fascination.

Direct and indirect effects of the physical attributes on preference

The values for preference ranged from low to moderate across the images, and they correlated strongly and positively with the values for restoration likelihood (see Table 1). Preference also correlated positively with the number of trees, their size and arrangement, and the presence of grass and flowers; however, the correlations for tree size and presence of grass were not significant.

When we substituted preference for restoration likelihood in the multivariate assessments of mediation, the results showed the

Table 3
Indirect effects of the association between the environmental components and restoration likelihood, through fascination.

	Point estimate	BC 95% confidence interval*	
		Lower	Higher
Number of trees	.20	.06	.34
Tree size	−.02	−.21	.18
Tree arrangement	.27	.07	.47
Presence of grass	.17	−.05	.40
Presence of flowers	.51	.27	.79

Note: N = 103 streetscape images.
* BC (bias corrected confidence interval) based on bootstrapped estimates. When the confidence interval does not include zero, the indirect effect can be regarded as statistically significant at $p < .05$.

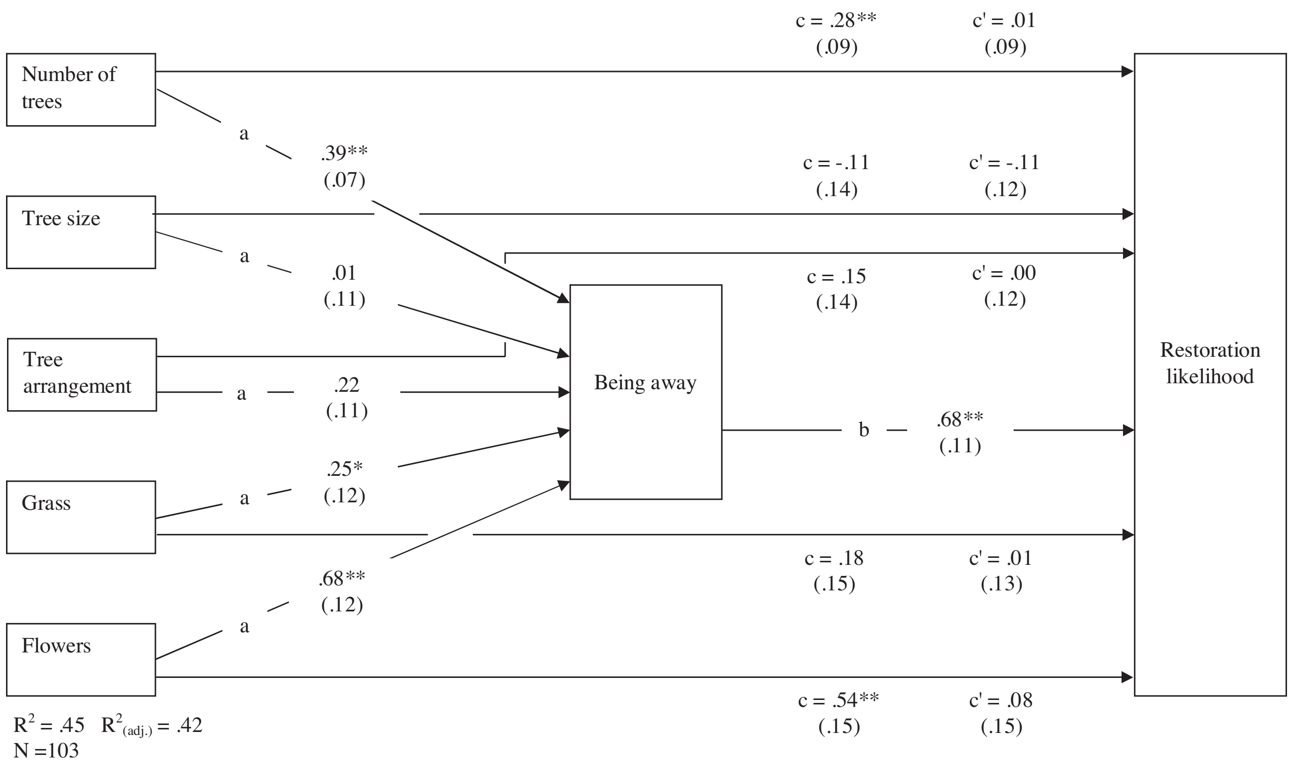

Fig. 2. Mediation model with being away as the mediator of the effects of physical environmental components of urban streetscapes on judgments of restoration likelihood. Unstandardized coefficients are shown with the corresponding standard errors in the parentheses. The paths marked (a) represent the effect of the physical components on the mediator. The path marked (b) represents the effect of the mediator on restoration likelihood. The paths marked (c) represent the effects of the physical components on restoration likelihood before adjustment for the mediator, though with adjustment for the other physical environmental component. The paths marked "c'" (c') represent the effects of the physical components on restoration likelihood after adjustment for the mediator. The difference between the values for c and c' represents the sum of the indirect effects transmitted through the mediator. $N = 102$. * $p < .05$; ** $p < .0001$.

same basic patterns seen in Figs. 2 and 3 for restoration likelihood, but with differences in the magnitude of some coefficients and greater amounts of explained variance ($R^2 = .76$ with being away as the mediator and $R^2 = .73$ with fascination as the mediator).

Interaction between the built environment and street vegetation

As indicated by the correlations in Table 1, the composite architectural characteristics of the buildings along the streets had strong effects on the environmental evaluations. The one-story buildings with moderate surface and silhouette complexity engendered higher ratings of restorative quality and restoration likelihood than the three-story buildings with low surface and silhouette complexity. These correlations affirm that the manipulation of architectural characteristics in the streetscapes had the effects expected on the basis of the findings of Lindal and Hartig (2013).

Looking to the possibility that the effect of streetside greenery would depend on the architectural characteristics of the buildings along the street, a multiple regression analysis revealed independent effects of the overall amount of vegetation ($b = .06$, SE $b = .01$, $\beta = .43$, $p < .001$) and the composite architectural characteristics ($b = 1.32$, SE $b = .09$, $\beta = .77$, $p < .001$), with the two variables explaining 72% of the variance in restoration likelihood ratings. One image was dropped from this analysis because it was a multivariate outlier. The interaction between composite architectural characteristics and amount of vegetation on judged restoration likelihood was however not significant ($b = -.02$, SE $b = .01$, $\beta = -.10$, $p = .17$). We also did not find any significant interaction in the series of five ANOVA (also $N = 102$) which crossed the composite architectural characteristics with one of the five vegetation variables (all $ps > .48$, all $\eta_p^2 < .015$). In each of these analyses, the effect size for the architectural variable was substantially larger than that for the vegetation variable; from twice as large in the analysis involving number of trees ($\eta_p^2 < .600$ versus .295) to nearly 19 times as large in the analysis involving grass ($\eta_p^2 < .603$ versus .032). The variance explained was substantial in each analysis (adjusted R^2 number of trees = .694; R^2 tree size = .627; R^2 tree arrangement = .614; R^2 grass = .597; R^2 flowers = .688).

Discussion

This study sheds light on the significance of streetside vegetation for restorative experience in urban residential streetscapes. A larger number of trees and the presence of flower beds beside buildings positively affected judgments of restoration likelihood. These effects appear to have been mediated by both of the restorative qualities in focus here; that is, trees and flower beds increased perceptions of being away and fascination, which in turn led to higher ratings of restoration likelihood.

Having trees on one versus both sides of the street did not appear to affect judgments of restoration likelihood, at least as initially seen in the bivariate correlation; however, when fascination was added as a mediator to a multivariate model which also adjusted for the effects of the other physical attributes, we found that having trees on both sides of the street did in fact contribute positively to restoration likelihood as expected. Similarly, the bivariate correlation between the presence of grass and restoration likelihood was not significant, but in a multivariate model with being away as the mediator we found the presence of grass did significantly increase restoration likelihood. These multivariate results, which take precedence over the bivariate correlations, are additionally interesting because they indicate that different

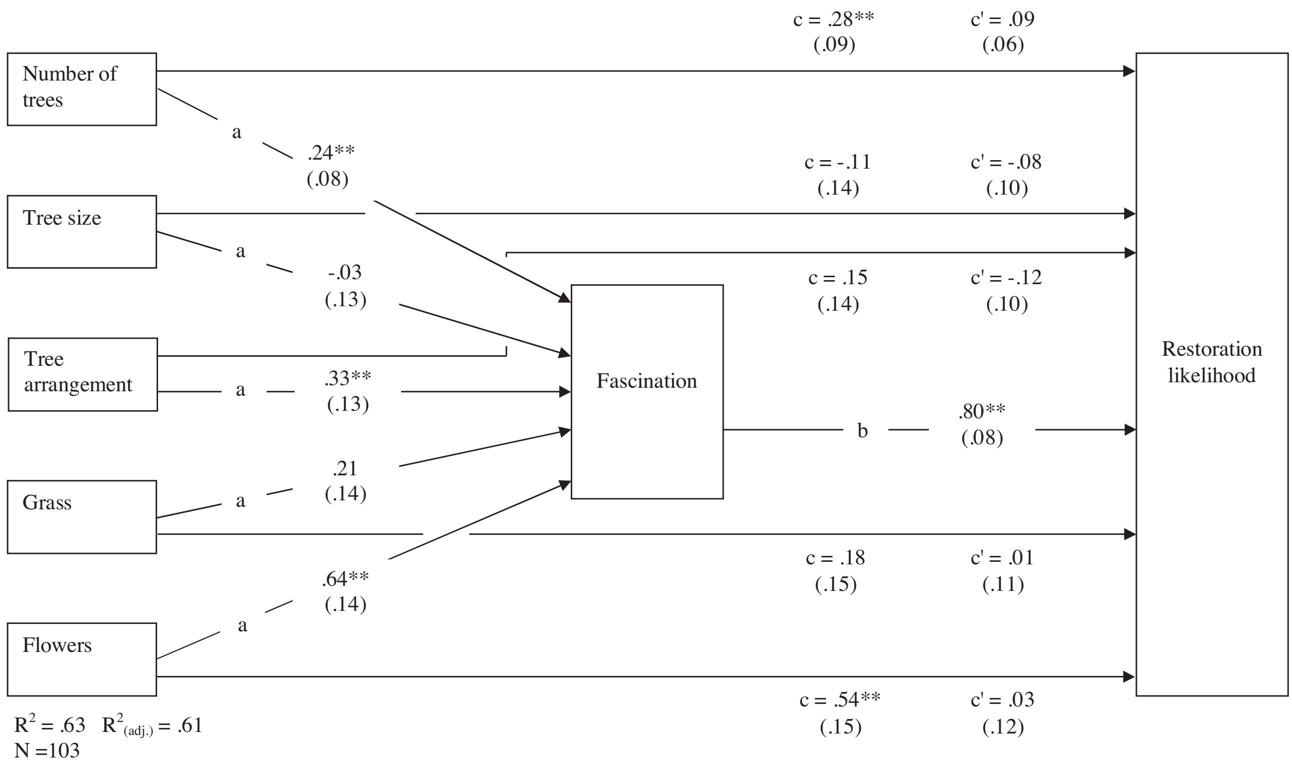

Fig. 3. Mediation model with fascination as the mediator of the effects of physical environmental components of urban streetscapes on judgments of restoration likelihood. Unstandardized coefficients are shown with the corresponding standard errors in the parentheses. The paths marked (a) represent the effect of the physical components on the mediator. The path marked (b) represents the effect of the mediator on restoration likelihood. The paths marked (c) represent the effects of the physical components on restoration likelihood before adjustment for the mediator, though with adjustment for the other physical environmental component. The paths marked "*c*′" (*c*′) represent the effects of the physical components on restoration likelihood after adjustment for the mediator. The difference between the values for c and *c*′ represents the sum of the indirect effects transmitted through the mediator. $N = 103$. * $p < .05$; ** $p < .0001$.

physical attributes of streetscapes can affect judgments of restoration likelihood through different components of restorative experience.

Not all effects were as expected. Of particular note, judgments of restoration likelihood did not increase with increasing size of trees. Conceivably, while the small and larger trees we used in our images differed substantially in height, the difference in the size of their canopies was too small.

We found no interaction between the composite of architectural properties and street vegetation. However, it should be noted that the streetscapes shown to have higher restorative potential on the basis of composite architectural characteristics (i.e., one story buildings with more façade details and peaked roofs) were not rated as highly restorative in some absolute sense, either in this study or in the study by Lindal and Hartig (2013). The difference in the restorative potential between the two streetscapes might have been too small to enable detection of an interaction. Conceivably, some form of interaction could emerge if a broader register of restorative quality had been covered by the architectural manipulations. In this regard, Bell et al. (2005) have noted that the addition of trees might sometimes reduce the esthetic quality of the environment by blocking beautiful facades or particularly appealing vistas. On the basis of the present results, however, the clearest conclusion that we can draw is that architecture and street greenery of different kinds had independent effects, and that the effect of architecture was clearly stronger.

Regarding preference, the study replicates previous findings showing a strong relationship between preference and restoration likelihood ratings (e.g., Nordh et al., 2009; Lindal and Hartig, 2013). On the whole, the results affirm our assumption that findings regarding environmental preference can be used as a source of guidance in identifying promising predictors of restoration likelihood, given gaps in the literature on specific physical attributes of environments that enhance restorative quality (Nordh et al., 2009; Velarde et al., 2007). This said, the results of the tests involving preference were not exactly like those for restoration likelihood. For example, the amount of variance explained in the multivariate analysis was substantially lower for restoration likelihood. This may reflect on the fact that in rating restoration likelihood the participants were asked to bear in mind a scenario of attentional fatigue. No such scenario was provided as a frame of reference for the ratings of preference. In any case, the results indicate that although the two dependent measures correlate strongly, they are indicators of different underlying constructs. Preference is a broader construct than restoration likelihood; people may like some environments more than others because they better support restoration, but they may also like environments to different degrees for reasons unrelated to restoration.

Limitations of the study and directions for further research

The present study has significant strengths, including the large sample of images with systematic manipulation of multiple physical attributes of immediate practical relevance. The study does however also have some limitations.

Some of these limitations have to do with features of our visual simulations. The use of two-dimensional images to present the streetscapes might be regarded by some as a weakness of the study, but we think this common validity concern has been well addressed in the literature, including the comprehensive meta-analyses by Stamps (1990, 2010). For example, both of his studies found strong correlations ($r = .86$) between ratings obtained with simulations versus on-site. Of course, on-site implies an existing environment, and our use of digital images anticipates the use of simulations to obtain evaluations of environments that do not yet exist. Although the images were not very sophisticated, they could be created at low cost, and they apparently represented the variation in most physical attributes sufficiently well for us to obtain reliable estimates of their effects. Still, they did force our participants to assume a particular vantage point, looking down the street from the close end. This vantage point is important; it affords the view of a pedestrian, driver or resident returning home who, turning onto the street, would begin to take in and evaluate its visual characteristics. We can only acknowledge, however, that some results might differ given a vantage point elsewhere on the street, where a person standing on one or the other sidewalk (or looking out a window) could have quite a different sense of the streetscape (cf. Wolf, 2004). Further research would therefore do well to consider other viewing options.

In this regard, dynamic representations available with virtual technologies offer many possibilities for studying future environments, including evaluations made with free exploration of virtual environments (VEs) and also the measurement of restorative effects of different VEs. High-performance graphical and display technology enable the creation of highly realistic, three-dimensional virtual urban environments in which design variables can be manipulated and confounding variables can be controlled (Rohrmann and Bishop, 2002). Although the potential utility of VEs in this research area has long been recognized (see also de Kort et al., 2006; Valtchanov et al., 2010), the VEs so far used do not to our knowledge make use of the kind of systematic manipulation of environmental attributes we have demonstrated here with two-dimensional images. We think a promising direction for future research is to assess the restorative effects of VEs constructed with previously evaluated digital images like those used in the present study (Lindal, 2013).

Other limitations of the present study have to do with the manipulations of the physical attributes in the creation of our images. The streetside vegetation and architectural background presumably can be elaborated in different ways to gain better estimates of their independent and interactive effects. As it stands, the ratings of the psychological variables generally fell within a narrow range at the low end of the scale, so there is clearly room for improvement in restorative quality. For example, we suggested earlier that the absence of the expected effect of tree size could follow from a too small difference in canopy volume, and restorative quality could increase given trees with larger canopies that spread across the street. Such differences in size and growth patterns align with tree age and other practical concerns of urban foresters, and image creation for future studies could more deliberately join concerns for restorative quality with specific concerns for design, care and management of urban greenery (cf. Nielsen and Møller, 2008). Image creation could also more deliberately address other issues in which concern for human benefits converges with concern for the environment, as with biological diversity. For example, increasing species diversity in trees, flowers, grass, other vegetation and the wildlife they attract could also increase visual diversity, which in turn could enhance restorative quality (cf. Fuller et al., 2007). Caution is warranted, however, as large amounts of vegetation may give an unwanted impression of lack of care and act as a problematic visual barrier in some contexts (cf. Wolf, 2004). Finally, image creation could take guidance from the literature on environmental preferences not only with regard to physical attributes that might contribute to restorative quality, but also with regard to ideas about how to organize those attributes in the given space (cf. Kaplan and Kaplan, 1989; Kaplan et al., 1998). Here we have used a quite simple approach, for example with equidistant placement of trees along sidewalks. Other arrangements might serve better if the primary concern is restorative quality.

The sample that rated the streetscape images might also be considered a limitation of the study. The low response rate does not necessarily mean non-representativeness, though it appears that our sample had a greater proportion of women than is found in the general population for the obtained age range, speaking to the operation of self-selection. Still, we had substantial variability in the sample as reflected for example in its age range; our streetscape images were rated by a heterogeneous group of Icelanders.

Finally, one might question the relevance of our data, in that the kind of residential environment presented in our images is relatively uncommon in the Icelandic context and Icelanders seem to have low familiarity with such environments. They do exist, however, and construction of more is an important topic of debate in Iceland as elsewhere. A large proportion of the Icelandic population has concentrated in the region of the capital, Reykjavik. Around 39% of the country's population is expected to live in Reykjavik by 2030, and until then it is expected that 90% of new residential units will be built in the current urban area (Department of Planning and Environment, 2013). This projection reflects the fact that planning professionals in Reykjavik, like their colleagues in many countries, have adopted a sustainability ideology critical of reliance on automobile transport and suburbanization (Reynarsson, 1999). Having evaluations of possible green urban futures involving greater residential densities should be of great help in Reykjavik as elsewhere when it is time to decide how development should proceed. It would nonetheless be interesting to see whether different results would be obtained from people in other sociocultural contexts where such environments are more familiar.

Conclusions

Our results agree with previous studies showing that the presence of natural elements can promote perceptions of restorative quality in urban environments (e.g., Todorova et al., 2004). They also affirm a proposal by Thwaites et al. (2005), which see streets together with a dense network of small, well-designed public spaces as serving the restoration needs of people in dense urban environments.

This study also contributes to the literature on restorative environments. It replicates the findings by Lindal and Hartig (2013), obtained with another Icelandic sample, showing the different impact of different street block architectural properties on restoration likelihood ratings. It also provides additional evidence that perceptions of being away and fascination mediate relationships between physical attributes of the environment and judgments of restoration likelihood. Furthermore, in that the indirect effects associated with being away and fascination differ, the study results speak to the effects of different physical attributes on different components of restorative quality.

The techniques used to create the environmental stimuli in this study also add value to the research on restorative environments. This study and its forerunner (Lindal and Hartig, 2013) have provided a platform for the creation of interactive three dimensional virtual urban environments, that can be used to carry out studies on restorative quality and actual restoration in virtual "field settings". This seems a promising approach to us, particularly in a time when urban densification calls for public input regarding ways to increase residential densities while also providing contact with nature and other opportunities for restorative experiences.

Author notes

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References

Bell, S., Blom, D., Rautamäki, M., Castel-Branco, C., Simson, A., Olsen, I.A., 2005. Design of urban forests. In: Konijnendijk, C.C., Nilsson, K., Randrup, T.B., Schipperijn, J. (Eds.), Urban Forests and Trees. Springer, New York, NY.

de Kort, Y.A.W., Meijnders, A.L., Sponselee, A.A.G., IJsselsteijn, W.A., 2006. What's wrong with virtual trees? Restoring from stress in a mediated environment. J. Environ. Psychol. 26, 309–320.

Department of Planning and Environment, 2013. Reykjavik Municipal Plan 2010–2030: July 2013 Proposal. Department of Planning and Environment, Reykjavik, Iceland: City of Reykjavik.

Enquist, M., Arak, A., 1994. Symmetry, beauty and evolution. Nature 372, 169–172.

Ewing, R., 1994. Residential street design: do the British and Australians know something Americans do not? Transp. Res. Rec. 1455, 42–49.

Ewing, R., Handy, S., Brownson, R.C., Clemente, O., Winston, E., 2006. Identifying and measuring urban design qualities related to walkability. J. Phys. Act. Health 3 (Suppl. 1), S223–S240.

Fuller, R.A., Irvine, K.N., Devine-Wright, P., Warren, P.H., Gaston, K.J., 2007. Psychological benefits of greenspace increase with biodiversity. Biol. Lett. 3, 390–394.

Getz, D.A., Karow, A., Kielbaso, J.J., 1982. Inner city preferences for trees and urban forestry programs. J. Arboric. 8, 258–263.

Gorman, J., 2004. Residents' opinions on the value of street trees depending on tree location. J. Arboric. 30, 36–44.

Grey, G.W., Deneke, F., 1978. Urban Forestry. John Wiley & Sons Inc., New York, NY.

Hartig, T., 1993. Nature experience in transactional perspective. Landscape Urban Plann. 25, 17–36.

Hartig, T., Korpela, K., Evans, G.W., Garling, T., 1997a. A measure of restorative quality in environments. Scand. Hous. Plann. Res. 14, 175–194.

Hartig, T., Kaiser, F.G., Bowler, P.A., 1997b. Further development of a measure of perceived environmental restorativeness. In: Working Paper No. 5. Institute for Housing and Urban Research, Uppsala University, Gävle, Sweden.

Hartig, T., Mitchell, R., De Vries, S., Frumkin, H., 2014. Nature and health. Annu. Rev. Public Health 35, 207–228.

Hartig, T., Staats, H., 2006. The need for psychological restoration as a determinant of environmental preferences. J. Environ. Psychol. 26, 215–226.

Hartig, T., van den Berg, A., Hägerhäll, C., Tomalak, M., Bauer, N., Hansmann, R., Ojala, A., Syngollitou, E., Carrus, G., van Herzele, A., Bell, S., Camilleri Podesta, M.T., Waaseth, G., 2011. Health benefits of nature experience: psychological social and cultural processes. In: Nilsson, K., Sangster, M., Gallis, C., Hartig, T., De Vries, S., Seeland, K., Schipperijn, J. (Eds.), Forests, Trees, and Human Health. Springer, Dordrecht, pp. 127–168.

Health Council of the Netherlands, 2004. Nature and Health: The Influence of Nature on Social, Psychological and Physical Well-being. Health Council of the Netherlands and Dutch Advisory Council for Research on Spatial Planning, Den Hague.

Herzog, T.R., Black, A.M., Fountaine, K.A., Knotts, D.J., 1997. Reflection and attentional recovery as distinctive benefits of restorative environments. J. Environ. Psychol. 17, 165–170.

Jacobs, A.B., 1997. Keynote: looking, learning, making. Places 1, 4–7.

Jiang, B., Chang, C.-Y., Sullivan, W.C., 2014. A dose of nature: tree cover, stress reduction, and gender differences. Landscape Urban Plann. 132, 26–36.

Kalmbach, K.L., Kielbaso, J.J., 1979. Resident attitudes toward selected characteristics of street tree plantings. J. Arboric. 5, 124–129.

Kaplan, R., Kaplan, S., 1989. The Experience of Nature: A Psychological Perspective. Cambridge University Press, New York, NY.

Kaplan, R., Kaplan, S., Ryan, R.L., 1998. With People in Mind: Design and Management of Everyday Nature. Island Press, Washington, DC.

Kaplan, S., 1995. The restorative benefits of nature: toward an integrative framework. J. Environ. Psychol. 15, 169–182.

Laumann, K., Garling, T., Stormark, K.M., 2001. Rating scale measures of restorative components of environments. J. Environ. Psychol. 21, 31–44.

Lindal, P.J., 2013. Restorative environmental design for densifying cities. In: Faculty of Architecture Design & Planning. University of Sydney, Sydney, Australia (Doctoral dissertation).

Lindal, P.J., Hartig, T., 2013. Architectural variation, building height, and the restorative quality of urban residential streetscapes. J. Environ. Psychol. 33, 26–36.

Lohr, V.I., Pearson-Mims, C.H., Tarnai, J., Dillman, D.A., 2004. How urban residents rate and rank the benefits and problems associated with trees in cities. J. Arboric. 30, 28–35.

Mitchell, R., Astell-Burt, T., Richardson, E.A., 2011. A comparison of greenspace indicators for epidemiological research. J. Epidemiol. Community Health 65, 853–858.

Nielsen, A.B., Møller, F., 2008. Is coppice a potential for urban forestry? The social perspective. Urban For. Urban Greening 7, 129–138.

Nordh, H., Alalouch, C., Hartig, T., 2011. Assessing restorative components of small urban parks using conjoint methodology. Urban For. Urban Greening 10, 95–103.

Nordh, H., Hartig, T., Hagerhall, C.M., Fry, G., 2009. Components of small urban parks that predict the possibility for restoration. Urban For. Urban Greening 8, 225–235.

Preacher, K.J., Hayes, A.F., 2008. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behav. Res. Methods 40, 879–891.

Portland Parks and Recreation City Nature Urban Forestry (no date). Street Tree Planting and Establishment Guidelines. City of Portland, OR, USA. Retrieved May 13, 2010 from ⟨http://www.portlandoregon.gov/trees/article/514074⟩.

Reynarsson, B., 1999. The planning of Reykjavik. Iceland: three ideological waves – a historical overview 14, 49–67, Plann. Perspect.

Rohrmann, B., Bishop, I., 2002. Subjective responses to computer simulations of urban environments. J. Environ. Psychol. 22, 319–331.

Schroeder, H.W., Orland, B., 1994. Viewer preference for spatial arrangement of park trees: an application of video imaging technology. Environ. Manage. 18, 119–128.

Schroeder, H.W., Flannigan, J., Coles, R., 2006. Residents' attitudes toward street trees in the UK and U.S. Communities. Arboric. Urban For. 32, 236–246.

Smardon, R.C., 1988. Perception and aesthetics of the urban environment: review of the role of vegetation. Landscape Urban Plann. 15, 85–106.

Sommer, R., Guenther, H., Barker, P.A., 1990. Surveying householder response to street trees. Landscape J. 9, 79–85.

Summit, J., Sommer, R., 1999. Further studies of preferred tree shapes. Environ. Behav. 31, 550–576.

Staats, H., Kieviet, A., Hartig, T., 2003. Where to recover from attentional fatigue: an expectancy-value analysis of environmental preference. J. Environ. Psychol. 23, 147–157.

Stamps, A.E., 1990. Use of photographs to simulate environments: a meta-analysis. Percept. Mot. Skills 71, 907–913.

Stamps, A.E., 1997. Some streets of San Francisco: preference effects of trees, cars, wires, and buildings. Environ. Plann. B: Plann. Des. 24, 81–93.

Stamps, A.E., 1999. Demographic effects in environmental aesthetics: a meta-analysis. J. Plann. Lit. 14, 155–175.

Stamps, A.E., 2010. Use of static and dynamic media to simulate environments: a meta-analysis. Percept. Mot. Skills 111, 355–364.

Tabachnick, B., Fidell, L., 2007. Using Multivariate Statistics, 5th ed. Pearson/Allyn & Bacon, Boston.

Texas Chapter of the International Society of Arboriculture (no date). Sec. 9-11-11. Tree ordinance. Retrieved May 14, 2010 from ⟨http://www.isatexas.com/members/Ordinances/2012_Ordinances/Public_Tree_Care_Ordinances/Coppell%20-%20Public%20Tree%20Care.pdf⟩.

Thayer, R.L., Atwood, B.G., 1978. Plants, complexity, and pleasure in urban and suburban environments. Environ. Psychol. Nonverbal Behav. 3, 67–76.

Thwaites, K., Helleur, E., Simkins, I.M., 2005. Restorative urban open space: exploring the spatial configuration of human emotional fulfillment in urban open space. Landscape Res. 30, 525–547.

Todorova, A., Asakawa, S., Aikoh, T., 2004. Preferences for and attitudes towards street flowers and trees in Sapporo Japan. Landscape Urban Plann. 69, 403–416.

Tomalak, M., Rossi, E., Ferrini, F., Moro, P., 2011. Negative aspects and hazardous effects of forest environment on human health. In: Nilsson, K., Sangster, M., Gallis, C., Hartig, T., de Vries, S., Seeland, K., Schipperijn, J. (Eds.), Forests, Trees, and Human Health. Springer, New York, NY.

van den Berg, A., Koole, S.L., van der Wulp, N.Y., 2003. Environmental preference and restoration: (How) are they related? J. Environ. Psychol. 23, 135–146.

van Dillen, S.M.E., de Vries, S., Groenewegen, P.P., Spreeuwenberg, P., 2012. Greenspace in urban neighbourhoods and residents' health: adding quality to quantity. J. Epidemiol. Community Health 66, e8.

Valtchanov, D., Barton, K.R., Ellard, C., 2010. Restorative effects of virtual nature settings. Cyberpsychol. Behav. Soc. Networking 13, 503–512.

Velarde, M.D., Fry, G., Tveit, M., 2007. Health effects of viewing landscapes: landscape types in environmental psychology. Urban For. Urban Greening 6, 199–213.

Weber, R., Schnier, J., Jacobsen, T., 2008. Aesthetics of streetscapes: influence of fundamental properties on aesthetic judgments of urban space. Percept. Mot. Skills 106, 128–146.

Wolf, K.L., 2003. Freeway roadside management: the urban forest beyond the white line. J. Arboric. 29, 127–136.

Wolf, K.L., 2004. Nature in the retail environment: comparing consumer and business response to urban forest conditions. Landscape J. 23, 40–51.

Wolf, K.L., 2009. Strip malls, city trees, and community values. Arboric. Urban For. 35, 33–40.