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The production of a Perceived Restorativeness Soundscape Scale

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Abstract

This paper presents the development and testing of a Perceived Restorativeness Soundscape Scale (PRSS). The scale is designed to assess perceptions of a soundscape's potential to provide psychological restoration. In study one, 123 participants were presented with audio-visual recordings from a UK urban, urban park and rural environment, which they rated using the created PRSS. A series of factor analyses resulted in a two factor solution consisting of a General Factor and a Being-Away-To and Coherence Factor to represent PRSS results and its theoretical components. An urban soundscape was perceived as lower in restorative potential than an urban park soundscape, which was perceived as lower in restorative potential than the rural soundscape. In study two, 194 participants used the developed PRSS to rate the soundscape of a UK urban park they had just visited. Factor analyses resulted in a General one Factor solution. The PRSS was able to differentiate between soundscapes from different urban parks. The success of considering a positive benefit of soundscapes, psychological restoration, via the PRSS is discussed.

Keywords

soundscape; perceived restorativeness; attention restoration; urban park.

1. Introduction

Negative mental and physiological problems, such as sleep disorder, stress, and reduced cognitive performances, which can arise from exposure to certain soundscapes, are well documented [1-3]. A number of measures have been developed to assess the negative perception of soundscapes including noise annoyance models [4], noise annoyance surveys [5]. In contrast, research into the positive role of soundscapes is less comprehensive. The preservation of quiet areas has been requested [6] and silence or quietness is often reported as a reason for visiting urban parks [7-8]. Besides reducing negative health effects, the value of these quiet and silent environments is less clear and increasingly there is converging evidence that physical measurements fail to capture various aspects of the subjective experience of sounds [9]. Moreover, soundscapes may provide positive effects, rather than just the absence of a negative effect and this may be irrespective of the sound level. Perhaps positive soundscapes may enhance a person's mood, may trigger a pleasant memory of a prior experience, or allow a person to relax and recover, both cognitively and physiologically (e.g. restoration). New perceptual measures that incorporate psychological and situational factors are therefore necessary to compliment physical acoustic measures for assessing the potentially positive role of soundscapes. This paper contributes to the assessment of one positive aspect of soundscapes by presenting research into the development of a scale to assess perceptions of their restorativeness.

Psychological restoration is the recovery from attentional fatigue and reflection upon daily or life issues [10-11]. Having opportunities for psychological restoration can help people's attentional performances [12] and support people's general well-being [13]. Attention Restoration Theory (ART) [11, 14] describes four components that are important for producing a restorative environment. These are Fascination, Being-Away, Compatibility and Extent (collectively referred to as FACE in this paper¹). Environments vary in the levels of each component, thus altering the overall restorative quality of each environment; it is the high presence or absence of these four components, that together, determine if an environment is restorative [14]. In theory, for prolonged and effective restoration, an environment needs to contain high levels of each component, while an environment with high levels of some components and low levels on others would have a reduced restorative potential.

Fascination is an alternative description for involuntary, effortless attention [11]. It is the ability of a stimulus to have attention-holding properties, without the individual needing to direct

¹ This acronym is courtesy of personal communication with Dr. K. Irvine.

attention to focus upon the stimulus, or to inhibit other stimuli from gaining attention. Thereby attentional resources are not drained and directed attentional fatigue does not occur.

Being-Away involves a physical or conceptual shift away from the present situation/problems to a different environment/way of thinking, allowing tired cognitive structures to rest while other ones are activated [11]. It has been proposed that there are two types of Being-Away; Being-Away-To and Being-Away-From [15]. The former involves the pull factors of Being-Away-To a novel place/task/cognitive thought, while the latter is the push factors of Being-Away-From a particular place/task/cognitive thought.

Compatibility is a component that depends on the individual as much as the environment. The environment needs to be responsive enough to an individual's planned behaviour and for the individual to have aims that fit the environment's demands [11]. A high match between the individual and the environment results in the individual using little directed attention as few differences need to be resolved, thus providing opportunities for restoration.

Extent refers to the coherency, scope and richness of an environment that enables the individual to feel as if it is one "whole other world" which has explorative potential [14](p173). Extent can be measured by its two subcomponents, Coherence and Scope [11]. Coherency relates to the connectedness of the elements in the environment with their structure and organisation combining to make sense (a coherent whole). Scope relates to the scale of the environment (imagined or physical) and what can be achieved there [11].

The perception of an environment's restorativeness depends on the individual's perception of the level of each FACE component. Perceived restorativeness scales have been developed to assess the perceived level of the FACE components for different environments [16-18]. These scales involve a number of items to measure each of the components. Multiple items are used to measure each component rather than one item per component to increase reliability, as is standard with psychological scales. Each component is measured to produce a clearer indication of all aspects of restoration. Together the component scores indicate the perceived psychological restorativeness of an environment; they measure the ability of an environment to give the impression that it has, or would, produce some level of psychological restoration. In general, natural environments are perceived as having greater restorative potential than urban environments, as they are perceived to contain higher levels of the FACE components [16-18]. This perception of potential restoration confers with people achieving higher levels of cognitive and physiological restoration in natural environments compared to urban environments [19-21].

Research examining the levels of each component within an environment has largely been analysed in terms of the visual features of a place, as many studies have involved the use of photos as stimuli [16-17, 22]. Sounds and soundscapes may also play a part in the potential for an individual to have a restorative experience [23-25]. If soundscapes can be restorative they should vary in their levels of Fascination, Being-Away, Compatibility and Extent. Indeed, descriptions of natural environments by blind people, whom experience places in part via its sonic environment, contained similar aspects to the definitions of FACE components [25]. Furthermore, if soundscapes relate to FACE components they could be assessed in terms of their perceived restorativeness using similar scales as those used with visual images.

The development of a soundscape specific perceived restorativeness scale would help shift the focus from a negative consideration of soundscapes, such as residential annoyance or urban noise pollution, to a consideration of the many positive benefits that can be derived from certain soundscapes, including psychological restoration. Such a shift in perspective could help protect certain places and 'positive soundscapes' from becoming less restorative than necessary, via planners' consideration of the sonic environment. Results from a Perceived Restorativeness Soundscape Scale (PRSS) would also be more powerful than descriptive findings of the SPL or a single pleasantness or restorativeness rating of a soundscape, for which the aspects of why it was 'pleasant' or 'restorative' would not be clear. The PRSS could determine if people would perceive having a positive, restorative outcome from experiencing such a soundscape, which is important for their cognitive and physiological well-being, and whether that perception occurred as it was a highly fascinating soundscape or if it provided a feeling of 'being-away'.

This paper presents two studies conducted to develop and test a Perceived Restorativeness Soundscape Scale (PRSS) that was designed and adapted from general perceived restorativeness scales [18, 20]. The first study is conducted in (semi) controlled conditions to test the ability of the PRSS to differentiate between soundscapes from three different types of environments (urban, urban park and rural environments). The second study is conducted *in situ* to test the ability of the PRSS to differentiate between soundscapes from two different places of the same environment type (urban parks). Specifically, the two studies aimed to create a reliable and valid PRSS that can differentiate between soundscapes with varying restorativeness qualities, in different (study one) and similar (study two) environment types.

2. Experiment One

The perceived restorativeness of soundscapes is expected to vary in a similar manner to environments in general; urban soundscapes are expected to be perceived as lower in restorative potential than natural soundscapes. This is for two reasons. Firstly, natural sounds tend to be preferred [26] and preferred environments are associated with restorative environments [27-28]. Secondly, soundscapes are part of people's experiences thus they are likely to contribute to the variation in the perceived restorativeness of environments in general. Therefore, the initial development of a Perceived Restorativeness Soundscape Scale was tested with this assumption of urban and natural differences. Urban park soundscapes were expected to be in between the urban and natural contrast of perceived restorativeness, as they often consist of both natural and urban sounds.

A number of similar attributes of perceived restorativeness scales and soundscape methodologies were used. This included the presentation of one representative place per environment type [18], using university students in classrooms as participants [16, 18-19], conducting the study after a lecture so that participants were in a naturally fatigued state [29], and participants imagining being in the presented environment [18, 30-31]. Importantly, the PRSS items are developed from perceived restorativeness scales [16, 18], adapting them to become sound specific, rather than for environments in general. Essentially, the main difference between this and other studies measuring perceived restorativeness is the focus upon sounds.

By using similar methodologies and procedures as previous studies, the PRSS results and prior perceived restorativeness scale results can be compared. This enables a partial validation test of the PRSS in two different ways. Firstly, from determining that there are four factors in the scale, one for each FACE component and secondly by determining that urban soundscapes are perceived as lower in restorative potential than rural soundscapes. Specifically, it was hypothesised that:

- the PRSS would contain separate factors for each FACE component [Fascination, Being-Away (-To and -From), Compatibility, and Extent (Coherence and Scope)].
- an urban soundscape would be perceived as significantly lower in restorative potential than an urban park soundscape, which would be perceived as significantly lower in restorative potential than a rural soundscape.

2.1. Method – Experiment One

2.1.1. *Participants*

Participants were a convenience, unpaid, sample of 1st year Town and Planning, and 1st and 2nd year Architecture students at the University of Manchester, UK. In total, there were 123 participants,

aged between 17 and 25 years (\bar{x} =19 years), where 52% were female. There were 40 participants in one condition, 38 in condition two, and 45 in condition three.

2.1.2. Stimuli

The stimuli included three audio-visual recordings, each lasting 2.5 minutes. These were continuous streaming footage of walks taken through an urban (Sheffield, UK, city centre), urban park (Sheffield, UK, Endcliffe park) and rural (area in the Peak District National Park, UK) environment on dry, sunny weekday lunchtimes in early March 2007. An example image taken en route in each environment is presented in Figure 1. The audio-visual recordings (videos) were created using a mini DV camcorder (Panasonic, NV-DS28) with an external 90 degree XY configuration cardioid stereo microphone (Røde, NT4) and windshield. The microphone was at ear level height, while the camcorder was just below eye height and generally pointed straight ahead, but with some surveying of the scene.



Figure 1: Example scenes from the urban (left), urban park (centre) and rural (right) environments.

The recording of the urban soundscape consisted of a general hum of indistinguishable sounds, vehicle related sounds (engines, horns, mechanical braking), snippets of people's conversations, people walking (footsteps), construction work (banging and drilling) and one brief moment of relative calmness because of wind on the microphone. The urban park soundscape consisted of a general hum of moving water from the stream, other natural sounds (gushing waterfall, birds twittering, ducks quacking), some construction work (banging from nearby site), and quiet snippets of people's conversations. The rural soundscape consisted of a general indistinguishable quiet background level, natural sounds (birds twittering in the trees, some wind, running water from a stream), the researcher's

footsteps (in the soggy grass underfoot, in the leaves and on rocks), a passer by saying hello and a gatepost being shut.

2.1.3. Apparatus

The stimuli were presented on two different audio-visual reproduction systems, because of participant availability. One condition, was conducted in a classroom and involved a 28” colour television with additional Yamaha Powered multimedia speakers (model YST-MS28), including 2 satellite speakers and a subwoofer, producing a 25 watt output. Condition 2 and 3 were conducted in the same lecture theatre which had its own integral audio-visual reproduction system, consisting of a large projection screen (4m x 2m) and two Ohm public address speakers in the top left and right hand corners of the room. The presentation order of the videos varied across the three conditions to control for some order effects (1: Urban Park, Rural, Urban; 2: Urban, Rural, Urban Park; 3: Rural, Urban, Urban Park).

2.1.4. Measures

2.1.4.1. Perceived Restorativeness Soundscape Scale

Nineteen items from perceived restorativeness scales of environments in general [16, 18] were adapted to be sound specific. Table 1 shows the five items for the theoretical component Fascination, three for Being-Away-To, three for Being-Away-From, four for Compatibility and four for Extent (three for Coherence and one for Scope). Items were measured on a seven point scale in response to ‘*how much do you agree with the statement...?*’ from *not at all* (0), *very little* (1), *a little* (2), *somewhat* (3), *a fair bit* (4), *very much* (5), *completely* (6).

Fascination

I find this sonic environment **appealing**

My **attention** is drawn to many of the interesting sounds here

These sounds make me want to **linger** here

These sounds make me **wonder** about things

I am **engrossed** by this sonic environment

Being-Away-To

I hear these sounds when I am **doing** something **different** to what I usually do

This is a **different sonic** environment to what I usually hear

I am hearing sounds that I **usually hear**

Being-Away-From

This sonic environment is a **refuge** from unwanted distractions

When I hear these sounds I feel **free** from work, routine and responsibilities

Listening to these sounds gives me a **break** from my day-to-day listening experience

Compatibility

These sounds relate to **activities** I like to do

This sonic environment **fits** with my personal preferences

I rapidly get **used to** hearing this type of sonic environment

Hearing these sounds **hinders** what I would want to do in this place

Extent (Coherence)

All the sounds I'm hearing **belong** here (with the place shown)

All the sounds merge to form a **coherent** sonic environment

The sounds I am hearing seem to fit **together** quite naturally with this place

Extent (Scope)

The sonic environment suggests the size of this place is **limitless**

Table 1: Perceived Restorativeness Soundscape Scale items grouped by Attention Restoration Theory Components. Words in bold are used to refer to the item in the text.

2.1.4.2. *Perceived sound quality*

As the audio recordings were presented under different experimental conditions, participants were also required to rate the sound quality of the presented audio recordings. Perceived sound quality was measured by presence (*the audio clip produced a sense of realism; that of being 'inside' the place rather than 'outside' of it*), envelopment (*the sounds seemingly wrapped around me, rather than coming from one location*) and depth (*the array of sounds seemed to be coming from many different distances from me*). All items were rated using the same seven point scale of *not at all* (0) to *completely* (6) agreeing with the statement. These were recoded in analysis to range from 1= low

spatial quality to 7 = high spatial quality. Items were inspired by discussions and items used for testing spatial qualities of audio reproduction systems [30-32].

2.1.4.3. Reverberation time

The reverberation time (RT_{60}) of the ‘experimental rooms’ (one lecture theatre, one classroom) were calculated from a mono-recording (using a Zoom H4 on a small tripod; 44.1kHz, 24bit) of an impulsive sound (popping a balloon) in the rooms when empty. The reverberation was calculated using the Schroeder reverse integration method [33]. The time taken for the sound to decay by 20dB of its peak amplitude was calculated and multiplied by three to obtain a measure of RT_{60} (s).

2.1.5. Procedure

Participants were asked, “*to imagine yourself in each of these environments. Imagine you are the person who is walking through and experiencing the environment. In particular I would like you to listen to the sounds around you*”. When the audio-visual playback had finished, the identical audio recording was played, without any visuals, while participants rated the soundscape using the Perceived Restorativeness Soundscape Scale and sound quality items. The procedure was repeated two more times for the other two environments, taking around 20 minutes in total to complete. Participants were thanked, debriefed and contact details provided.

2.2. Analysis

To assess if participants’ three perceived sound quality items (dependent variables) varied depending on their experimental condition (independent variables), three MANOVAs (Multivariate Analysis of Variance) were conducted, one for each environment. The audio recordings of all three environments’ did not significantly differ in perceived sound quality ratings across conditions (Wilks’ $\lambda=.90, .98$ and $.96, p>.05$, for the urban, urban park and rural soundscape respectively). Generally, participants’ perceived sound quality of the urban, urban park and rural audio recordings was very good ($\bar{x}=4.86, \sigma=1.33; \bar{x}=4.81, \sigma=1.11; \text{median}=5$, respectively). Similar reverberation times of 0.28 and 0.33 seconds were measured for the classroom and lecture theatre respectively. These reverberation times reflected the decay time of high frequencies, and are lower than if low frequencies were also incorporated, however, these measures were considered adequate for comparing the two rooms. Overall, despite the use of different audio-visual equipment and rooms, the perceived sound quality and reverberation times for the three conditions were similar, suggesting the participants were exposed to similar conditions. Therefore, their results can be combined, allowing analysis of all 123 participants together as if they had been in the same room.

For analysis, PRSS ratings were recoded from 0 to 6 into 1 to 7. Less than one per cent of the PRSS data was missing. These values were replaced with average scores from fellow *a priori* FACE components. Three variables (urban *belong*, rural *belong*, rural *together*) had negatively skewed distributions that were corrected by reflection and square root transformations. All other PRSS items were also reflected for a comprehensible factor analysis. A small value (1) represents high perceived soundscape restorativeness and a large value (7) represents low perceived soundscape restorativeness. The three transformed PRSS items are used for the factor analysis, but not for calculating individual factor scores and reliability scales (for each of the items grouped together to represent a component).

2.3. Results – Experiment One

A series of analyses were conducted to assess the relationship between the items and the theoretical FACE components they represented, as well as for determining the most appropriate factor structure for the developed PRSS items. The series of analyses replicated the procedure used for developing a perceived restorativeness scale [18] and relates to general scale development processes [34-35]. The series of analyses were replicated three times, one for each environment type.

First, preliminary Principal Axis Analysis (PAA) was conducted to determine the success of each individual PRSS item in only representing one FACE component. A PAA with a five factor structure (based on eigenvalues more than 1) was conducted three times, once for each environment type. Items with joint high ($>.35$) or low ($<.35$) loadings across the factors were flagged up, as this suggested these items did not represent one sole factor. Five items (*usually hear*, *break*, *used to*, *hinders*, *together*) that had joint high or low loadings in two or three of the environments' were removed.

Second, the remaining items for each of the *a priori* FACE components produced reliable sub-scales (Cronbach's $\alpha >.7$, or mean inter item correlation $.2 < \bar{r}_i < .4$; these are the optimum ranges for reliability [36]), except for the three items measuring the Extent of the urban soundscape ($\bar{r}_i = .07$). Third, to determine the number of factors necessary for explaining variance in the data of the remaining 14 PRSS items, a Principal Component Analysis (PCA) was conducted for each environment. A two factor structure was determined to be appropriate for all three environments, by comparing eigenvalues generated from each environment's PCA and random generated eigenvalues calculated from a Monte Carlo PCA for parallel analysis [37].

Finally, a Principal Axis Analysis (PAA) with oblique rotations and a forced two factor solution was conducted for each environment. Results slightly varied across the three environments as items did not load on identical factors. The pattern and structure loadings are presented in Table 2, along

A priori FACE components	PRSS Item	URBAN					URBAN PARK					RURAL				
		Pattern Matrix(a)		Structure Matrix		Commu -nalties	Pattern Matrix(a)		Structure Matrix		Commu -nalties	Pattern Matrix(a)		Structure Matrix		Commu -nalties
		Factor		Factor			Factor		Factor			Factor				
		1	2	1	2		1	2	1	2		1	2			
Fascination	Appealing	0.69	-0.15	0.70	-0.17	0.51	0.73	-0.15	0.72	-0.09	0.54	0.78	-0.13	0.76	-0.04	0.60
	Attention	0.53	-0.08	0.54	-0.09	0.29	0.66	-0.07	0.65	-0.02	0.43	0.66	0.17	0.68	0.24	0.49
	Linger	0.75	-0.03	0.75	-0.05	0.56	0.75	-0.07	0.75	-0.02	0.56	0.77	0.07	0.78	0.16	0.61
	Wonder	0.56	0.26	0.56	0.25	0.38	0.55	0.06	0.56	0.10	0.31	0.57	0.19	0.59	0.25	0.38
	Engrossed	0.66	0.10	0.66	0.09	0.44	0.50	-0.10	0.49	-0.06	0.25	0.66	-0.04	0.65	0.03	0.43
Being-Away- To	Doing Different	-0.06	0.64	-0.07	0.64	0.41	0.10	0.37	0.13	0.38	0.16	0.00	0.69	0.08	0.69	0.48
	Different Sonic	-0.06	0.45	-0.07	0.46	0.21	-0.07	0.43	-0.04	0.42	0.18	-0.25	0.55	-0.19	0.52	0.34
Being-Away- From	Refuge	0.35	0.45	0.34	0.44	0.32	0.58	0.13	0.59	0.17	0.36	0.63	0.18	0.65	0.25	0.45
	Free	0.53	0.13	0.53	0.12	0.30	0.65	0.13	0.66	0.17	0.45	0.73	0.08	0.74	0.17	0.56
Compatibility	Activities	0.58	-0.22	0.58	-0.23	0.39	0.58	-0.52	0.54	-0.48	0.56	0.72	-0.24	0.69	-0.16	0.53
	Fits	0.80	-0.33	0.81	-0.34	0.76	0.79	-0.22	0.78	-0.17	0.65	0.86	-0.30	0.82	-0.20	0.77
Coherence (Extent)	Belong	0.07	-0.49	0.08	-0.49	0.25	0.46	0.42	0.49	0.45	0.42	0.15	0.28	0.18	0.30	0.11
	Coherent	0.29	-0.22	0.29	-0.23	0.13	0.64	0.32	0.66	0.37	0.54	0.36	0.47	0.42	0.51	0.39
Scope (Extent)	Limitless	0.44	0.32	0.43	0.31	0.29	0.52	0.14	0.53	0.18	0.30	0.46	0.00	0.46	0.05	0.22

Table 2: Pattern and structure matrix results of the Principal Axis Analysis two factor structures of the PRSS items for each environment type. Numbers in bold indicate higher loadings across the factors for each matrix. Grey shading indicates the factor structure.

with the communalities (variance accounted for that variable by the factors). For all three environments, the first factor explained most of the variance in PRSS scores (26, 33, 35% for the urban, urban park and rural soundscape respectively), with the second factor explaining comparatively little (10, 7, 10% for the urban, urban park and rural soundscape respectively).

To be able to compare Factor scores across environments, the same factor structure for all three environments was necessary. Therefore, the loading of individual items on each factor, for each environment were compared, to determine one factor structure suitable for all three environments. Only three items loaded on different factors across the three environments, *refuge*, *belong*, and *coherent*. An examination of the loading values and reflection on the reliable *a priori* scales, decided which factor these items were designated too to enable comparisons across environments. The resultant final factor structure was the same as the factor structure for the rural soundscape. This resulted in a General Factor (1) consisting of ten items (all five Fascination, both Being-Away-From, both Compatibility and both of Extent's Scope items) and a Being-Away-To and Coherence Factor (2) consisting of four items (both Being-Away-To and both of Extent's Coherence items). As the PRSS did not have separate factors for each FACE component, the first hypothesis is rejected.

The two factors were reliable scales for all three environments (Cronbach's $\alpha > .7$, or mean inter item correlation $.2 < \bar{r}_i < .4$) except the Being-Away-To and Coherence Factor for the urban environment ($\bar{r}_i = -.15$). Two factor scores were calculated for each participant, for each environment, to represent their perceived restorativeness of each environment. These were calculated by averaging each participants' ratings on the 10 items for the General Factor score and the 4 items on the Being-Away-To and Coherence Factor. This method was chosen as the coefficients could not calculate Factor scores for each item as an altered factor structure was used for the urban and urban park environment. This was needed to compare Factor scores across environment types.

Mean PRSS scores and paired sample *t*-tests for both the General Factor (1) and the Being-Away-To and Coherence Factor (2) revealed that the urban soundscape was perceived as significantly lower in restorative potential than the urban park soundscape ($t = -10.97$ and -10.82 , $p < .001$ respectively), which was perceived as significantly lower in restorative potential than the rural soundscape ($t = -4.79$ and -5.18 , $p < .001$). The urban soundscape was also perceived as significantly lower in restorative potential than the rural soundscape for both the General Factor and the Being-Away-To and Coherence Factor ($t = -12.05$ and -13.18 , $p < .001$ respectively). Standard deviations were small for each environment and Factor's mean score; Factor 1 $\sigma = .97, .92, 1.13$, Factor 2 $\sigma = .74, .88, .93$ for urban, urban park, and rural respectively. Overall, the second hypothesis was supported, as the urban soundscape was perceived as significantly lower in restorative potential than the urban park

soundscape, which was perceived as significantly lower in restorative potential than the rural soundscape (see Figure 2).

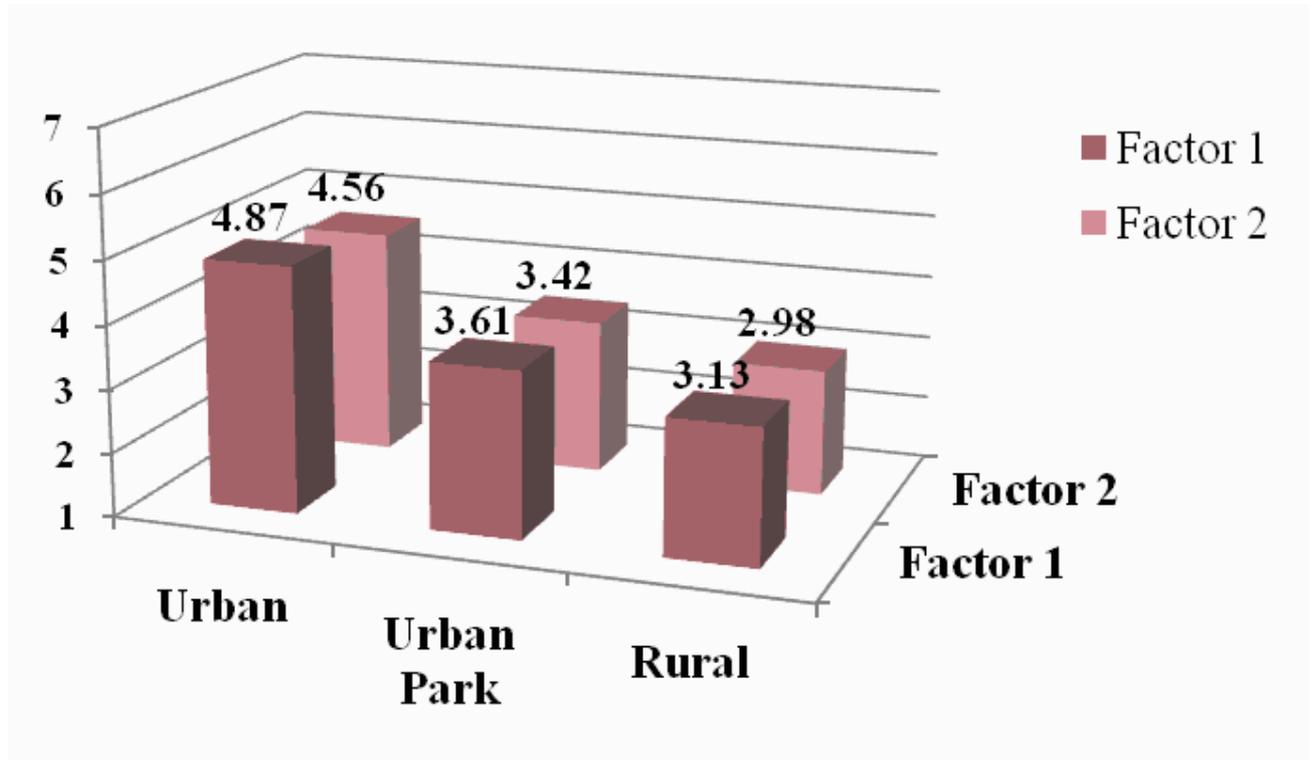


Figure 2: Factor 1 and 2 mean Perceived Restorativeness Soundscape Scale scores for each environment type (7=low restorativeness, 1=high restorativeness).

2.4. Discussion – Experiment One

The aim of this first study was to develop and partially validate a Perceived Restorativeness Soundscape Scale (PRSS) by testing its ability to produce four factors (one for each FACE component) and to differentiate between soundscapes from three different types of environments (urban, urban park and rural environments). Overall, there was mixed support for the reliability and validity of the PRSS.

Firstly, the PRSS produced a two factor structure, with one General Factor (Fascination, Being-Away-From, Compatibility and Scope) and one Being-Away-To and Coherence Factor. This differs to the theorised four factor structure and empirical five factor structure (two factors for Being-Away) found in one previous perceived restorativeness scale[18]. This could suggest that there are theoretical differences between the components that create the PRSS and the general perceived restorativeness scales. However, this was the first development stage of the PRSS and two factor structures were also

produced in early development stages of a general perceived restorativeness scale that the PRSS items were modelled on [16]. Therefore, there was some level of concurrent validity, but improvements to some items to ensure they measure one of the theoretical components in relation to soundscapes may still be necessary.

In similarity with a general perceived restorativeness scale [18] and reasons for visiting urban parks [15], Being-Away-To and Being-Away-From PRSS items were separated into two different factors. The separation of these components also matches differences in lay descriptions of soundscapes. For example, within urban and residential environments, people might want to get away *from* the everyday soundscape, which is generally referred to with negative terms such as noisy [38-39]. In contrast, people may want to get away *to* peaceful, calm, and tranquillity soundscapes that are often expected of natural and rural environments [40]. The separation of these items however may relate to the comprehension of these particular items as they may have been easier, or harder, for the participants to understand in relation to the soundscape. Further research into the comprehension of the individual items would be necessary to explore this point.

The two aspects of Extent, Coherence and Scope, were also separated by the final PRSS structure (based on the factor structure of the rural environment). This reflected their separation in a two factor structure of a general perceived restorativeness scale [16]. However, this was not true for the original factor structure of the urban park and urban environment in this study, therefore, it is unclear whether Coherence and Scope are different aspects within the perceived restorativeness of a soundscape.

Secondly, the two PRSS Factors produced reliable scales, as did the *a priori* subscale items for each FACE component. This suggests the individual PRSS items were successful conversions of the perceived restorativeness scale items, as they maintained the content validity of prior FACE components.

Thirdly, as predicted, an urban soundscape was perceived as significantly lower in restorative potential than an urban park soundscape, which was perceived as significantly lower in restorative potential than a rural soundscape. Therefore, the PRSS was successful at discriminating between the soundscapes from the three different environment types in the expected manner. This is similar to perceived restorativeness scales of the environment in general, thus again satisfying concurrent validity, albeit cautiously, as no direct comparison of PRSS scores and perceived restorativeness scale scores were made.

3. Experiment Two – *in situ* study

Newly developed scales should also be tested *in situ* with comparable results between *in situ* and experimental conditions being desirable. Indeed, general perceived restorativeness scales have been tested in both experimental and *in situ* conditions [16]. Additionally, by using only students in the previous study, the results may not be representative of the general population. Therefore, the production of similar results in different conditions, with a variety of participants (general public) would support the generalizability of the developed Perceived Restorativeness Soundscape Scale. Moreover, the value of the PRSS as a measure of the perceived restorativeness of soundscapes would increase if it differentiated between soundscapes from places of the *same* environment type (e.g. urban parks), as well as across different environment types, as in the prior study.

Two urban parks (Western Park and Botanical Gardens) were chosen that are located less than 1.5 miles from the city centre of Sheffield, UK, are 0.7 miles apart from each other, and have residential housing, hospitals and Universities nearby. Sound pressure levels in the parks were measured on a Tenma 72-860 sound level meter, at a height of 130cm. Measurements were made every 10 seconds for 5 minute periods, every other hour, between 10am and 7pm, at 8 or 9 locations throughout the two parks for 7 days (4 in Weston Park, 3 in Botanical Gardens) in July. Importantly, the soundscape and SPL of these two parks significantly differed [$t(247.63)=-2.98, p<.01$] because of their different sizes, location, surrounding roads and general function. The smaller and slightly louder Weston Park [$\bar{x}=60.2\text{dB(A)}, \sigma=5.57; 4.82 \text{ ha}$] has fewer natural elements (less herb and tree canopy layer [41]) than the larger and quieter Botanical Gardens [$\bar{x}=58.6\text{dB(A)}, \sigma=6.46; 6.93 \text{ ha}$]. In accordance with the urban-natural continuum of the perceived restorativeness of soundscapes, identified in study one, Weston Park soundscapes were therefore expected to be perceived as lower in restorative potential than Botanical Gardens soundscapes.

This study therefore aimed to test the developed PRSS *in situ* with visitors' perception of soundscapes in two urban parks. It was hypothesised that:

- the PRSS would contain two factors representing FACE components (General Factor and Being-Away-To and Coherence Factor). This would be in line with the previous study.
- the PRSS would differentiate between soundscapes from two different urban parks, with the smaller, louder, Weston Park soundscapes being perceived as lower in restorative potential than the larger, quieter, Botanical Gardens soundscapes.

3.1. Method – Experiment Two

3.1.1. *Participants*

Summer visitors (July to early September 2007) leaving either of the two urban parks (between 10am and 7pm on weekdays and 10am to 5.30pm on weekends) were asked to participate in the *in situ* questionnaire study. In total, 194 urban park visitors participated without compensation (n=96 Weston Park), 61% on a weekday, aged between 15 and at least 76 years (median=35 to 44 years), 47% female, with 49% from Weston Park.

3.1.2. *Measures – Perceived Restorativeness Soundscape Scale*

The PRSS consisted of the remaining 14 items developed and analysed in study one. It consisted of five items for Fascination, two for Being-Away-To, two for Being-Away-From, two for Compatibility, two for Extent's Coherence and one for Extent's Scope². Items were again measured on a seven point scale in response to 'how much do you agree with the statement...?' from *not at all* (0), *very little* (1), *a little* (2), *somewhat* (3), *a fair bit* (4), *very much* (5), *completely* (6).

3.1.3. *Procedure*

As urban park users left the park, they were asked to participate in a study about people's experiences of urban parks, in particular about their visit/use of the park that day. Participants were informed that all responses would be treated anonymously and confidentially and they had the right to withdraw at any time. Among other questions about their experience in the park, participants answered the 14 item Perceived Restorativeness Soundscape Scale. Upon completion, participants were thanked, debriefed and any questions answered.

3.2. Analysis

For analysis, PRSS ratings were again recoded from 0 to 6 into 1 to 7. Three per cent of the PRSS data was missing. Two percent of these values were replaced with average scores from fellow *a priori* FACE components. The other one percent was replaced by the item's overall mean value, as other items for that *a priori* component were missing for that participant.

² Some of the PRSS items in the second study were slightly adapted versions of those in study one. It was necessary to alter the tense of the items, as participants were recalling the soundscape they had just experienced in the park. One Compatibility item that was referred to as *fits* was altered to improve its comprehension and is referred to as *matched* in the second study. Unfortunately, a Coherence item used in study one (*All the sounds merge to form a coherent sonic environment*) was accidentally replaced in study two by another Coherence item that had been removed from analysis (*The sounds seemed to fit together quite naturally with this park*).

Six of the variables had negatively skewed distributions, which were addressed by reflection and square root (*appealing, wonder, free, matched*) or reflection and log (*belonged, together*) transformations. All other PRSS items were reflected for a comprehensible factor analysis. The six transformed PRSS items are used for the factor analysis and individual factor scores, but not for calculating reliability scales.

3.3. Results – Experiment Two

A series of analyses were conducted on the combined set of results from the two parks to assess the relationship between the items and theoretical FACE components. This determined the most appropriate factor structure for the developed PRSS items when used *in situ* within one type of environment. The series of analyses replicated the procedure used for testing the PRSS in study one. The preliminary PAA had a five factor structure and suggested that five items be deleted from further analysis due to joint high or low loadings. A Fascination item (*attention*), both Being-Away-To items (*doing different* and *sonic different*), a Compatibility item (*activities*) and a Coherence item (*belong*) were removed.

The remaining nine PRSS items each produced adequately reliable *a priori* FACE component scales, except Compatibility, which was only represented by one item (*The sonic environment matched my preferred sonic environment*). Fascination had four items in its reliable sub-scale (Cronbach's $\alpha=.74$, $\bar{X}_r=.42$; *Overall, I found the sonic environment appealing; The sounds made me want to linger in the park; The sounds allowed me to wonder about things in general; I was engrossed by the sonic environment*). Being-Away-From had two items in its reliable sub-scale (Cronbach's $\alpha=.70$; $\bar{X}_r=.54$; *The sonic environment was a refuge from unwanted distractions; When I hear those sounds, I feel free from work, routine and responsibilities*). The two Extent items together formed a reliable sub-scale ($\bar{X}_r=.28$; Coherence: *The sounds seemed to fit together quite naturally with this park*; Scope: *The sonic environment suggested the size of this park is limitless*).

A PCA and Monte Carlo PCA for parallel analysis [37] suggested extracting one factor to explain data variance. A PAA with oblique rotations and one extracted factor resulted in the nine PRSS items explaining 44% of the variance in the scores. Together the nine items formed a very reliable PRSS Factor (Cronbach's $\alpha=.88$). Factor items, communalities and Factor score coefficients are presented in Table 3.

Factor 1 FACE Components	PRSS Item (transformation)	Factor matrix	Communalities (extraction)	Factor score coefficient
Fascination	Appealing (sqrt)	0.68	0.46	0.14
	Linger	0.68	0.46	0.15
	Wonder (sqrt)	0.62	0.38	0.11
	Engrossed	0.59	0.34	0.11
Being-Away-From	Refuge	0.76	0.58	0.22
	Free (sqrt)	0.73	0.53	0.19
Compatibility	Matched (sqrt)	0.73	0.53	0.19
Coherence (Extent)	Together (log)	0.57	0.32	0.10
Scope (Extent)	Limitless	0.56	0.32	0.09

Table 3: Factor matrix results of the PAA one factor structure of the PRSS items. (Only one factor matrix is produced unlike in table 2 which has a pattern and structure matrix, as here there is only one factor).

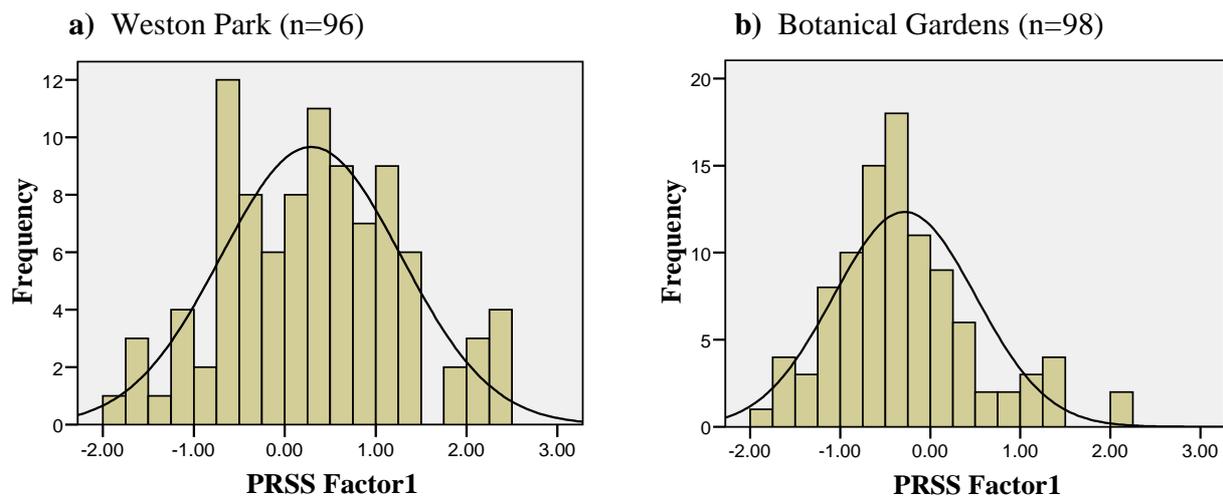
As the final PRSS factor analysis structure consisted of only one General Factor, the hypothesis is rejected. The *in situ* urban park PRSS results did not contain a General Factor and a Being-Away-To and Coherence Factor, similar to the resultant factor structure from the urban, urban park and rural PRSS experimental study.

Individual participants' PRSS ratings for their perceived soundscape were calculated from the coefficients developed from the regression method³ of the forced one factor PAA solution (see Table 3). This meant the mean of all the scores is set at zero, converting the range of participants' Factor scores to -2 (low restorativeness) to 2.35 (high restorativeness). The PRSS General Factor scores for participants in Weston Park significantly differed to those in Botanical Gardens [$t(181.43)=4.47$, $p<.001$]. The mean PRSS Factor score in Weston Park ($\bar{x}=.29$, $\sigma=.99$) significantly differed to the mean PRSS Factor score in Botanical Gardens ($\bar{x}=-.28$, $\sigma=.79$); on average Weston Park soundscapes were perceived as lower in restorative potential than Botanical Gardens soundscapes. Weston Park soundscapes were sometimes perceived as high in restorativeness and other times very low in

³ This is the most appropriate way to calculate individual scores. It could not be used in experiment one as each environment type had coefficients based on different factor structures, thus, not all the coefficients related to the final chosen (forced) factor structure necessary to compare environments. Therefore coefficients could not be used in experiment one to calculate individual scores.

restorativeness (see Figure 3a). In contrast, the restorativeness of Botanical Gardens soundscapes varied less and were frequently perceived as high in restorativeness (see Figure 3b). The hypothesis is supported as the PRSS significantly differentiated between soundscapes from two places of the same environment type, urban parks.

Figure 3a and 3b: Perceived Restorativeness Soundscape Scale Factor scores in two urban parks (-2=low restorativeness, 2.35=high restorativeness).



3.4. Discussion – Experiment Two

This study aimed to further develop the Perceived Restorativeness Soundscape Scale (PRSS) and assess its ability to differentiate between soundscapes within one environment type. Overall, there was mixed support for the success of the PRSS. The FACE components were represented by one General Factor instead of two or four. The reliable General Factor differentiated between the perceived restorativeness of soundscapes across two urban parks.

The production of one General Factor and absence of the Being-Away-To and Coherence Factor that was identified in the first study, is likely considering only one item from the Being-Away-To and Coherence Factor remained in the latter analysis stages of this second study. Moreover, a comparison of the final nine remaining PRSS items in the second study, were all the items (bar the one Coherence item) that created the General Factor in the original urban park factor structure in the first study. Therefore, the factor structure for the PRSS rated by the general public in an urban park, *in situ*, is similar to the factor structure for the PRSS rated by students for an urban park soundscape presented in experimental conditions. This similar factor structure, identified in different conditions (experimental and *in situ*) and using different groups of people (students and public), suggests the nine

remaining items in the PRSS are partially standardised. One factor structures have also been used in prior research involving general perceived restorativeness scales, as the second factors were generally disregarded because of low explained variance contributions [22, 27]. Additionally, the high reliability value of the General Factor (nine items), suggests the scale as a whole is still reliable in assessing the same concept. Therefore, as with prior research, it can be concluded that the one General Factor is suitable for measuring the perceived restorativeness of the soundscape.

The PRSS General Factor scores successfully differentiated between two urban parks, with different sound levels and identified soundscapes [42]. As predicted, on average, Weston Park soundscapes were perceived as lower in restorative potential than soundscapes from the more natural Botanical Gardens. There was greater variation in the perceived restorativeness of Weston Park soundscapes than in Botanical Gardens, despite greater variation in SPL in Botanical Gardens. This suggests that specific types of sounds and their associated meanings were more important in influencing the perceived restorativeness of the soundscape than its overall SPL. These differences and the ability of the PRSS to differentiate between the restorativeness of soundscapes from two urban parks increases the value of the PRSS as a measure of the perceived restorativeness of the soundscape.

4. Overall Discussion

The two studies successfully created a reliable, partially validated and partially standardised Perceived Restorativeness Soundscape Scale. The developed versions of the PRSS differentiated between the perceived restorativeness of soundscapes across different environment types (study one) and within an environment type (study two), as perceived by students (study one) and the general public (study two). The scale is therefore sensitive enough to rate the quality of soundscapes, in terms of their perceived restorativeness, in one place in comparison to another. This could help suggest which locations may need alterations to enhance the restorativeness of the soundscape.

In the first study, factor loadings of individual PRSS items differed across the three environments, resulting in 3 different factor structures. This suggests the interpretation of items was slightly altered depending on the type of soundscape being rated. A more consistent factor structure across different environments would be desirable, although differences in factor structures across environments have also been noted in results of general perceived restorativeness scales [16]. Developing items that can maintain a stable meaning across a wide range of environments would be useful.

The separation of one factor per FACE component, or highly reliable sub-scales of *a priori* FACE components within each factor is still desirable. This would allow the relative importance of

each FACE component to be reliably evaluated. Without this separation, the scale is limited in its capabilities to provide information on the theoretical component that is lowering the perceived restorativeness soundscape rating. For example, nearly half of the items in the final solution of the PRSS General Factor were Fascination items (four out of nine), while Being-Away-From items had higher coefficient values. Therefore, for the comparison of the two urban parks, the results would have been biased by perceived Fascination and Being-Away-From scores. Inclusion in the PRSS, of an equal number of items per FACE component and enough items to provide highly reliable sub-scales would enable a thorough exploration of the different types of restorative elements (FACE components) that each urban park provides. Such knowledge could help determine which aspects of the soundscape could be enhanced to increase the potential restorativeness of the soundscape.

The amount of variance explained by the factors totalled around 36-45% in the first study and 44% in the second study. This is a fairly substantial amount of explained variance, although lower than perceived restorativeness scales of environments in general, which varied from 35 to 70% explained variance [18, 22, 43]. Again, improvements to the scale could increase the explained variance. Additionally other factors could also cause variance in the data scores including individual differences such as noise sensitivity, awareness of sounds and level of prior fatigue. Moreover, visual factors could also be influencing ratings on the perceived restorativeness of the soundscape, as the soundscape is not experienced in isolation. Multi-sensory interactions can influence soundscape evaluations [44-45] thus differences in these experiences may need to be accounted for when interpreting PRSS ratings.

5. Conclusion

A Perceived Restorativeness Soundscape Scale was developed through an iterative process. Its reliability and validity was tested via comparisons with perceived restorativeness scales designed for measuring environments in general, rather than sounds specifically. The PRSS was sensitive to differentiations between the restorativeness of soundscapes from different environment types (urban, urban park and rural) and of the same environment type (urban parks). The scale was able to demonstrate the ability to consider the potential positive role of soundscapes in terms of perceived restorativeness.

Although successful, further work on developing and testing the PRSS is necessary and is currently on going. For example, the interpretation of the items by the general public needs to be explored as well as the generation of more items to provide an equal representation of all FACE components. This should increase comprehension and aid a cleaner factor structure. The relative contribution of each FACE component to the restorative character of soundscapes can then be

examined. This could make the PRSS an informative tool that could benefit planning officers and design professionals in aiding their urban planning decisions/designs to help produce a sustainable urban environment.

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