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Predicting perceived tranquillity in urban parks and open spaces

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ABSTRACT

A method is described which allows an assessment to be made of the state of tranquillity of an amenity area such as park, green or square. The method involves the assessment of traffic noise levels and the measurement of the percentage of natural and contextual features using photographs of the scenes. Examples are taken from three amenity areas in Bradford, West Yorkshire. Using published noise maps sampling was taken at points in the three parks where visitors are likely to be found and where noise levels were likely to be highest and lowest. At these locations predictions were made of the traffic noise levels and then the tranquillity rating and the mean value and distribution of ratings were compared. Recommendations for improving the perceived tranquillity are discussed.

1. INTRODUCTION

The need for tranquil spaces is widely recognised for example the British Government's Rural White Paper[1] acknowledged that tranquillity, and a lack of noise and visual intrusion, are key factors that contribute to the unique character of the British countryside. Indeed a survey conducted by the UK's Department for Environment, Food and Rural Affairs (DEFRA)[2] showed that 58% of people questioned stated that for them tranquillity was the most positive feature of the British countryside. In addition there are health benefits in experiencing tranquillity in nature. However, relatively tranquil environments in urban spaces may be more important to the nation's well-being than rural tranquil spaces, as they enable people to easily escape the daily cognitive overload that characterises modern living. Attention Restoration Theory proposes that exposure to natural restorative environments can help us recover from the 'sensory overload' that characterises everyday urban life, by providing us with the opportunity to reflect on life's priorities, possibilities and goals[3,4]. Other studies investigating effects on stress levels show that recovery is significant more rapid when people are exposed to natural rather than man-made environments[5]. A more recent development is an examination of the evidence for "nature-deficit disorder" which is claimed seriously limits the development of children[5a].

Previous research at the University of Bradford has shown that it is possible to predict with reasonable accuracy the perceived tranquillity on a rating scale using two factors: the average noise level from man-made noise sources and the percentage of natural features in the landscape such as vegetation, water and geological features e.g. exposed rock outcrops[6]. The research has been carried out in the laboratory using video cuts of outdoor binaural recordings in a variety of landscapes from open moors through beach scenes and residential areas to city centres.

Current research has refined the prediction formula by including more sites using funding from EPSRC grant EP/F055986/1. The revised formula relating these factors is given by:

$$TR = 10.185 + 0.0409\, NCF - 0.156\, L_{Aeq} \qquad (1)$$

where TR is the tranquillity rating on a 0 to 10 rating scales. NCF is the percentage of natural and conformal features and L_{Aeq} is the equivalent constant A-weighted sound pressure level.

More recently the natural features variable has been expanded to include contextual features such as listed buildings, religious and historic buildings, landmarks, monuments and elements of the landscape, such as traditional farm buildings, that directly contribute to the visual context of the environment. It can be argued that when present, these visually cultural and contextual elements are as fundamental to the construction of 'tranquil space' as are strictly natural features.

Tranquillity assessments were obtained from subjects under controlled simulated environments in an anechoic chamber. The subjects were provided with Technics RP– 295 headphones and positioned 2m from the centre of a 42" Pioneer PDP–506XDE plasma screen. They were then asked to rate how tranquil they found 11 locations to be when presented with audio only, video only and combined audio-video data streams. Each location was scored on a scale of 0 – 10, with 0 representing 'not at all tranquil' and 10 representing 'most tranquil', and the stimuli were presented in a balanced design intended to reduce order effects. Prior to the experiment the subjects were told that for the purpose of the research a tranquil environment was one that they considered a quiet, peaceful place to be, i.e. a place to get away from everyday life.

In order to use the prediction tool in practice it is necessary to consider appropriate sampling techniques which will identify the range of likely tranquillity ratings in the chosen areas and then to address inadequacies in predicted tranquillity by "what if" analyses.

3. BACKGROUND

Surveys were carried in 3 contrasting parks and green areas in the Bradford City area where the dominant source of noise was from road traffic:

- Lister Park: a large park triangular in shape (approx. 560m x 220m) adjacent to a major radial route into the city centre with a day time flow of 1300 vehicles/hr. Contains mature, trees, formal gardens, iconic building (Cartwright Hall) and boating lake, sports area and children's playground
- Thackley Green: a simple rectangular grassed open space (approx. 100m x 35m) with few trees and no formal gardens. Adjacent to a major route to Leeds and with an industrial estate to the rear. Day time flow 910 vehicles/hr.
- Peace Garden: a rectangular space (approx. 55m x 14m) on the edge of the University of Bradford campus and adjacent to a route into the city centre with a day time flow of 1060 vehicles/hr. Recently developed to include 1.8m high noise screening wall, herbaceous borders containing mature trees and a small pond with water feature.

The approach was to identify the most likely tranquil and non-tranquil spaces in three contrasting parks and greens and calculate the Tranquillity Rating using:

- Noise maps provided by DEFRA
- Spot readings of A-weighted sound pressure levels
- Noise predictions based on the UK traffic noise prediction model CRTN
- Photographic survey of the percentage of natural and contextual features

A. Noise Maps

The noise maps are published on the DEFRA website at: www.http://noisemapping.defra.gov.uk. They were used to help identify the likely nosiest and quietest areas in the selected parks and greens. The noise bands are given in L_{den} and are in 5 dB(A) intervals down to 55 dB(A). Levels below 55dB(A) are not differentiated so the maps are only useful at a strategic level of investigation. L_{den} by definition includes day, evening and night-time levels, weighted according to human sensitivity to noise, and therefore are not directly relevant to the daytime use of the parks in question. To convert to L_{day} (average day time level from 7am to 7pm) a formula derived for the UK national survey was used[7].

$$L_{day} = 0.984\ L_{den} - 0.196 \quad (2)$$

B. Spot Readings

During the photographic surveys spot readings of the A-weighted sound pressure level were taken of background noise levels which was dominated by traffic noise. Periods of significant natural sounds were excluded (e.g. bird song) as were human voices and the noise from any other mechanical sounds (if present). In conjunction with the noise maps the quietest and nosiest locations were determined. GPS co-ordinates were recorded using a hand held device (Garmin eTrex HC) at these locations.

C. Noise Predictions

Since the dominant noise source at each site was road traffic noise, predictions were carried out at the sites using CRTN[8]. This method predicts the 18 hour L_{A10} value from 0600 to 2400 hours. Classified traffic counts were carried out and distances to the nearest road was calculated using GPS co-ordinates previously recorded. At all sites the road surface was essentially level with a bituminous wearing course and subject to a 48 km/h (30 mile/h) speed limit.

It is suggested that this method is used where an accurate prediction is required. The L_{day} can then be obtained from the official conversion formulae[9]:

For non-motorways: $L_{day} = 0.95\ L_{A10,18h} + 1.44$ dB (3)

For motorways: $L_{day} = 0.98\ L_{A10,18h} + 0.09$ dB (4)

Note that where CRTN is not the preferred prediction method other validated traffic noise models can be used to obtain L_{day}. Where noise from other transportation modes are dominant the L_{day} value can be calculated using the appropriate prediction model.

D. Photographic Survey

Having identified the quietest and noisiest areas from the relevant noise maps and spot readings, the percentage of natural and contextual features was determined using a camera giving a field of view of approximately 51 degrees in the horizontal plane on a normal (non-zoom) setting. Seven contiguous pictures were taken at a height of 1.5m (close to the average standing eye height of adults in the UK) to give an approximate field of view of 360 degrees. These pictures were pasted into Microsoft PowerPoint and analysed using a 10 x 10 grid placed over the images to determine the percentage of natural and contextual features.

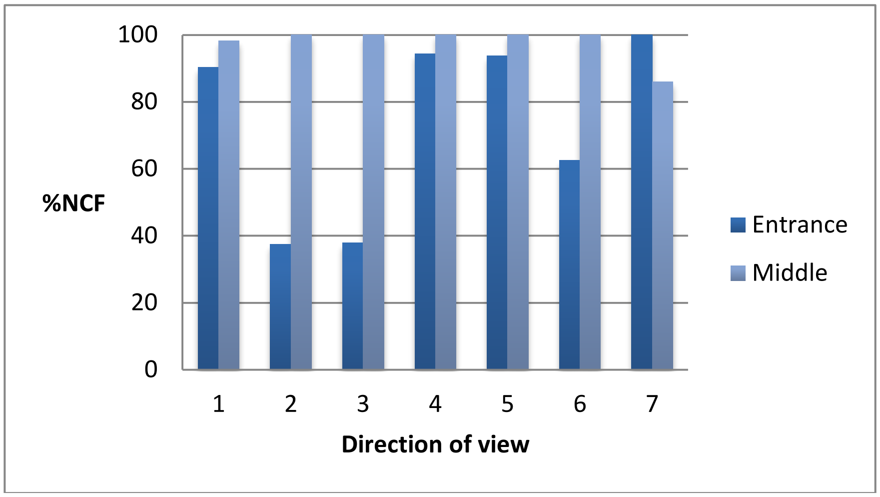
In all cases the quietest areas also had the highest percentage of natural features so according to the prediction tool this would also be the most tranquil. In the formal parks survey positions were chosen on pathways as it was observed that few people crossed grassy areas or walked through or over plants and vegetation.

4. ANALYSIS

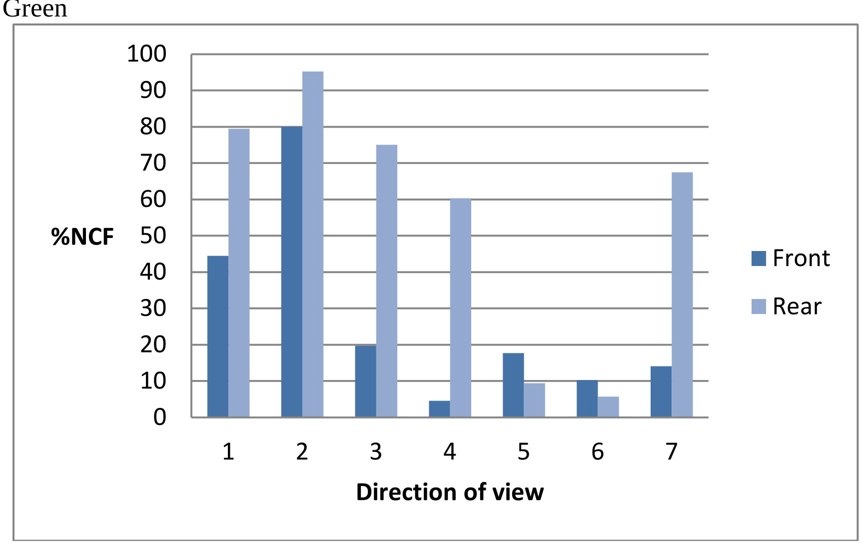
The proportion of natural and contextual features calculated from the photographic survey is show in Figures 1a to 1c. It can be seen that in all cases the middle or rear of the parks contained the highest percentage of natural features. Close to the major roads the scenes were often dominated by the road, parked and passing vehicles and buildings (e.g. houses, garages, walls) and roadside furniture (speed cameras, signals and signs). Away from the major road the grass, trees and contextual buildings and walls tended to dominate the scenes.

Figure 2 shows views of Lister Park, Thackley Green and the Peace Garden illustrating typical views at each position.

(a) Lister Park



(b) Thackley Green



(c) Peace Garden

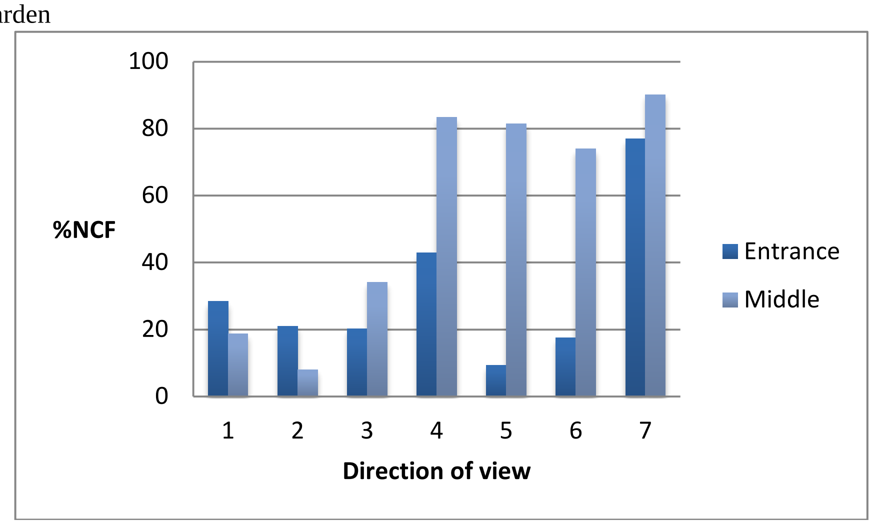


Figure 1*:* Percentage of natural and contextual features

Lister Park: *Near entrance* *Centre*

Thackley Green: *Near main road* *Rear*

Peace Garden: *At entrance* *Centre*

Figure 2: Typical views at three study sites

Table 1 summarises the calculated L_{day} values using the noise prediction method CRTN and the percentage of natural and contextual features from the photographic survey together with the corresponding predicted Tranquillity Rating

Table 1: Predicted tranquillity rating

Location	**L_{day} (dB(A))**	**Percentage of natural and contextual features**	**Predicted tranquillity rating**
Lister Park			
In middle	51.8	97.7	6.1
Near south-east entrance	69.0	73.7	2.4
Thackley Green			
At rear	60.4	56.1	3.1
By main road	75.7	27.3	-0.5
Peace Garden			
At centre	60.7	55.6	3.0
At east entrance	70.0	30.9	0.5

5. DISCUSSION OF TRANQUILLITY RATING TOOL

It can be seen that the predicted tranquillity rating ranged from -0.5 adjacent to the main road at Thackley Green to 6.1 at the centre of Lister Park where the most tranquil space was to be found. In an attempt to give an indication of acceptable and non-acceptable levels of the tranquillity rating it is suggested that based on the author's collective experiences the following provisional guidelines should apply:

<5 unacceptable
5.0 – 5.9 just acceptable
6.0 – 6.9 fairly good
7.0 – 7.9 good
≥ 8.0 excellent

If these descriptors apply then from Table 1 it can be seen that the highest level in Lister Park falls in the "fairly good" category.
To obtain acceptable levels of tranquillity where currently TR$<$ 5.0 it will be necessary to consider:

(a) Reducing transportation noise
(b) Increasing the percentage of natural features

In most cases it will be most cost effective to concentrate efforts on producing tranquil areas away from noise sources and in the middle of areas with trees, shrubs and flower beds. Local screening of the noise sources is possible e.g. use of walled gardens and noise screening at source can be affected by purpose built noise barriers or better still a decorative wall (see Figure

2, Peace Garden) . Diversion of heavy traffic and the use of low noise road pavements are further possibilities.

Due to its size relatively large areas in the middle of Lister Park have fairly good levels of tranquillity however the study has highlighted short comings at Thackley Green and the Peace Garden. For Thackley Green increasing the percentage of natural features close to the road to 100% would still produce an unacceptable low tranquillity rating of 2.5. However away from the road towards the rear of the Green the planting of shrubs to surround this area would be predicted to yield a nearly acceptable rating of 4.9. Another potential solution would be to build a 2m high fence or wall close to the road to partially screen the traffic noise from the major road. In this case it should be possible to achieve a noise level reduction of say 4 dB(A) at the rear. However, the tranquillity rating would rise to only 3.7 which can be considered “unacceptable”. In such cases this illustrates the potentially more cost effective solution of planting shrubs rather than building a noise barrier.

For the Peace Garden there are major constraints to improving the tranquillity rating further since the park is narrow and lies adjacent to a major route into the centre of the city. A 1.8m wall had been constructed to reduce the effects of traffic noise but despite this noise levels are still fairly high (L_{day} = 60.7 dB(A)). In addition there is a building on one side of the park which cannot easily be screened with shrubs and trees because of the problem of allowing daylight into the ground floor windows. However, it may be possible to allow plantings close to the seating areas at the centre of the park using for example rose arches, trellising with climbing plants etc which would improve the percentage of natural features present. If 100% natural features could be achieved then a rating of 4.8 would be the predicted outcome. This illustrates the problem of producing acceptable tranquillity very close a busy urban road. In this situation as well as increasing the amount of natural features it may be necessary to consider the benefits of the water feature as this has been shown to improved perceived tranquillity.

It should be noted that there are a number of factors that are not contained within the prediction tool which are likely to degrade or improve the tranquillity rating beyond that which has been predicted. These include biological, geological, social and personal safety factors. For example it is considered the following are influential:

Degrading factors:

- presence of litter and graffiti
- ugliness
- restricted views
- presence of large numbers of people
- amplified music, car alarms, sirens, ice cream chimes

Improving factors:

- areas of water and associated water sounds
- bird song, animal and some insect sounds
- gentle sounds in vegetation produced by wind
- open views
- sunshine
- flowers
- pleasant fragrances

The strength and direction of some of these factors have been explored in an earlier phase of the study which involved the tranquillity ranking of a wide range of images ranging from building sites through gardens to coastal scenes. 100 pictures were ranked for tranquillity by over 100 volunteers of all ages. The mean rank was then calculated and used to test the strength of the relationship with some of the factors thought most influential.

The size of the correlation coefficient (Spearman rank, rho), the direction and statistical significance are given in Table 2 below. For each factor the percentage of the area in the scene (excluding the sky) covered has been determined and used to rank the different scenes. These rankings were then compared with the mean ranking on perceived tranquillity.

Table 2: Spearman rank correlation coefficient, rho, with tranquillity rank

Percentage of natural features	Percentage of flora	Percentage of water	Percentage of fauna	Percentage of people	Number of people
0.78^{**}	0.42^{**}	0.32^{**}	0.02^{NS}	-0.36^{**}	-0.32^{**}

*** p<0.01, NS p>0.05*

The beneficial effect of a factor is indicated by a statistically significant correlation coefficient ($p<0.05$) while a negative effect is conversely given by a significant negative correlation coefficient. It was expected that the highest correlation would be the percentage of natural features since this includes flora and fauna and water which individually are related to tranquillity. Since not many of the images contained fauna the strength of the relationship was difficult to test. Currently research using a variety of water sounds has indicated more directly the beneficial effects of the sounds of running water on perceived tranquillity[10].

Further work will help to quantify these moderating factors. However as a guide to assessing tranquillity the prediction tool is potentially a practical aid in the design of urban and rural spaces. If required the influence of such moderating factors can at present be used in a qualitative manner in reaching an overall assessment of perceived tranquillity.

6. CONCLUSIONS

Previous research at the University of Bradford has involved the investigation of the environmental factors which facilitate subjectively perceived tranquillity. Statistically significant factors that have been identified are the noise level (L_{Aeq} or L_{Amax}) and the percentage of natural and contextual features in the visual scene. To apply the prediction tool in practice it is necessary to consider the likely range of the tranquillity rating for a given amenity area. A practical technique of predicting, measuring and sampling the important variables are described with examples taken from 3 contrasting green spaces in an urban area. Additional influential factors are also considered and means of improving tranquillity are discussed at the two of the study sites where the predicted tranquillity was considered unacceptable.

REFERENCES

[1] Department for Environment Food and Rural Affairs, *Rural White Paper*. (DEFRA, UK. 2000).

[2] Department for Environment Food and Rural Affairs, *Survey of Public Attitudes to Quality of Life and the Environment*. (DEFRA, UK. 2001).

[3] S. Kaplan and R. Kaplan, “The Experience of Nature: a psychological perspective”. (New York: Cambridge University Press. 1989).

[4] S. Kaplan, “The restorative benefits of nature: Towards an integrated framework”, *Journal of Environmental Psychology*, **15,** 169-182 (1995).
[5] R. S. Ulrich, R. F. Simons, B. D. Losito, E. Fiorito, M. A. Miles and M. Zelson, “Stress recovery during exposure to natural and urban environments”, *Journal of Environmental Psychology*, 11, 201-230 (1991).
[5a] R. Louv, *Last child in the woods: saving our children from nature-deficit disorder* (Algonquin books of Chapel Hill, 2008).
[6] R. J. Pheasant, K. V. Horoshenkov, G. R. Watts, B. T. Barrett, “ The acoustic and visual factors influencing the construction of tranquil space in urban and rural environments: tranquil Spaces – Quiet Places?” *Journal of the Acoustical Society of America*, **123**, 1446 – 1457 (2008)
[7] C.J. Skinner and C.J. Grimwood, survey, *The UK National Noise Incidence Study 2000/2001*(BRE, Watford, WD25 9XX. UK. 2002).
[8] Department of Transport and WelshOffice. *Calculation of Road Traffic Noise*. (HMSO, London. 1988).
[9] http://www.defra.gov.uk/environment/noise/research/crtn/pdf/noise-crtn-update2006.pdf
[10] G. R. Watts, K. V. Horoshenkov, R. J. Pheasant and L. Ragonesi, “Investigation of Water Generated Sounds for Masking Noise and Improving Tranquillity”, CD-ROM, Proceedings of Internoise 2008, Shanghai, October 26th 2008.