Article:

Watts, G, Khan, A and Pheasant, R (2016) Influence of soundscape and interior design on anxiety and perceived tranquillity of patients in a healthcare setting. Applied Acoustics, 104. C. pp. 135-141. ISSN 0003-682X

https://doi.org/10.1016/j.apacoust.2015.11.007

Influence of soundscape and interior design on anxiety and perceived tranquillity of patients in a healthcare setting

Greg WATTS[1]; Amir KHAN[2]; Rob PHEASANT[3]

[1,2,3] University of Bradford, UK

ABSTRACT

Tranquillity characterised by a pleasant but calming environment is often to be found in natural environments where man-made noise is at a low level though natural sounds can be relatively high. Numerous studies have shown a link between such restorative environments and hospital recovery rates, stress reduction, longevity, pain relief and even how the brain processes auditory signals. In hospitals and primary care facilities there is a need to improve patient waiting rooms as current designs are largely based solely on medical need. There are often long waits in such spaces and patients are coping with the stress and anxiety caused by their medical condition. Attention should therefore be given to creating "restorative environment" as a component to their medical treatment. The study describes the effects of introducing natural sounds and large images of natural landscapes into a waiting room in a student health centre. Using self reported levels of anxiety and tranquillity it was possible to assess the impact that these targeted auditory and visual interventions had in affecting the quality of the patient experience. Following the changes results show that levels of reported tranquillity were signicantly improved but there were smaller change in reported reductions in anxiety.

Keywords: Soundscape, tranquillity, healthcare

1. INTRODUCTION

Tranquil spaces are often natural environments where man-made sounds are not dominant. Past research has shown that such environments improve hospital recovery rates, reduce stress, improve

[1] g.r.watts@bradford.ac.uk
[2] a.khan117@bradford.ac.uk
[3] r.j.pheasant2@bradford.ac.uk

longevity, reduce pain and can affect how the brain processes auditory signals [1, 2, 3, 4, 5, 6]. A useful and comprehensive overview of this area of research has been provided recently [7].

Previous work on elucidating the tranquillity of environments has largely focused on prediction and validation using the Tranquillity Rating Prediction Tool, TRAPT [8,9,10,11]. This prediction method includes two important factors: the level of man-made noise and the percentage of natural and contextual features in the visual scene. The percentage of natural features in the landscape includes vegetation, water and geological features e.g. exposed rock outcrops. Contextual features include listed, religious and historic buildings, landmarks, monuments and elements of the landscape such as traditional farm buildings and dry stone walls that directly contribute to the visual context of the natural environment. Examples of excluded elements are: built up areas, energy infrastructure (such as pylons, wind turbines and dams), transportation infrastructure and recreational facilities These human artefacts introduce an element of visual discontinuity within the landscape that can result in a perceived lack of contextual coherence[12].

Based on these factors TRAPT allows the prediction of the tranquillity of a place on a 0 to 10 scale. It is proposed to extend the model to inform the design of interior spaces and especially in healthcare centres where it is important to reduce stress to facilitate better mood, well being and outcomes of treatment. The method proposed involves intervention research where changes are made in a live setting and evaluations are obtained from users of the facility. Note that the approach adopted here departs from some architectural practices in that the proposed study to inform design of restorative spaces is evidence based and certainly does not try to capture the latest trends of fashionable design.

Among other facilities in hospitals and primary care facilities there is a need to improve patient waiting rooms as current designs are largely based solely on medical need. From previous experience there are often long waits in such spaces and patients are coping with the stress and anxiety caused by their medical condition. Attention should therefore be given to creating “restorative environments” as a component to their medical treatment. All too often a lack of understanding of the influence of interior space on well being and budget constraints have led to the adoption of “hard” architecture consisting of plain walls and ceilings, little or no wall art, no greenery or flowers and little consideration of the view from the windows, if incorporated. Further the acoustic environment or soundscape is often characterised by consistently high sound levels due to reflections from hard surfaces of noise emitted from people and equipment; such as mobile phones and monitoring apparatus. Almost it frequently appears that little consideration is given to noise reduction strategies despite detailed hospital guidelines on noise control [13]. There are a number of studies that illustrate these problems. For example, in the reception area at the entrance to a hospital emergency department levels of L_{Aeq} ranged from 65 to 73dB(A) due to the constant flow of patients, doctors, nurses, and moving equipment [14]. However, sound level is only one aspect of the soundscape. In order to improve healthcare environments it is important to understand the role of sound and to determine what may be positive, negative, and the feelings that different soundscapes can evoke [15]. Therefore it should be relatively easy to identify such areas within current designs of many primary care centres and hospitals, though exceptionally some designs may already be informed by such considerations and there may be little room for improvement

2. METHOD

2.1 Study area

The Bradford Student Health Service (BSHS) located within walking distance of the University of Bradford campus has a waiting room that fitted well with experimental requirements since it was necessary to treat an area which was reasonably well isolated from the rest of the facilities so that the effects of any environmental “treatments” that are applied as part of the study are not contaminated by sounds or views from outside the study area.

The treatments that was applied to the room was limited by a consideration of the needs of staff, doctors and the Practice Manager, plus the budget available and the time constraints. Obviously the size and quality of the impact of any treatment will depend on the number of improving factors introduced and their scale.

Figure 1 shows a dimensioned plan (in metres) of the waiting room. Seating was arranged around the edges of the room and there were 4 noticeboards where health related notices were displayed. In a prominent position a monitor screen gave patient prompts as appointments became due. The room has an ordinary shoe box shape with the exception of a reception area. The room volume is approximately 75m^3 and the average reverberation time measurement (RT60) for the room was 0.55sec. This was the average of three measurements made with B&K 2165 microphone and Nexus amplifier connected to PC running winMLS at 48kHz sampling rate. The impulse sound source was produced by bursting a balloon. This reverberation time for the waiting room was considered to be within acceptable limits for the use intended. The cushioned seats and sound absorptive ceiling would have contributed to this relatively low value.

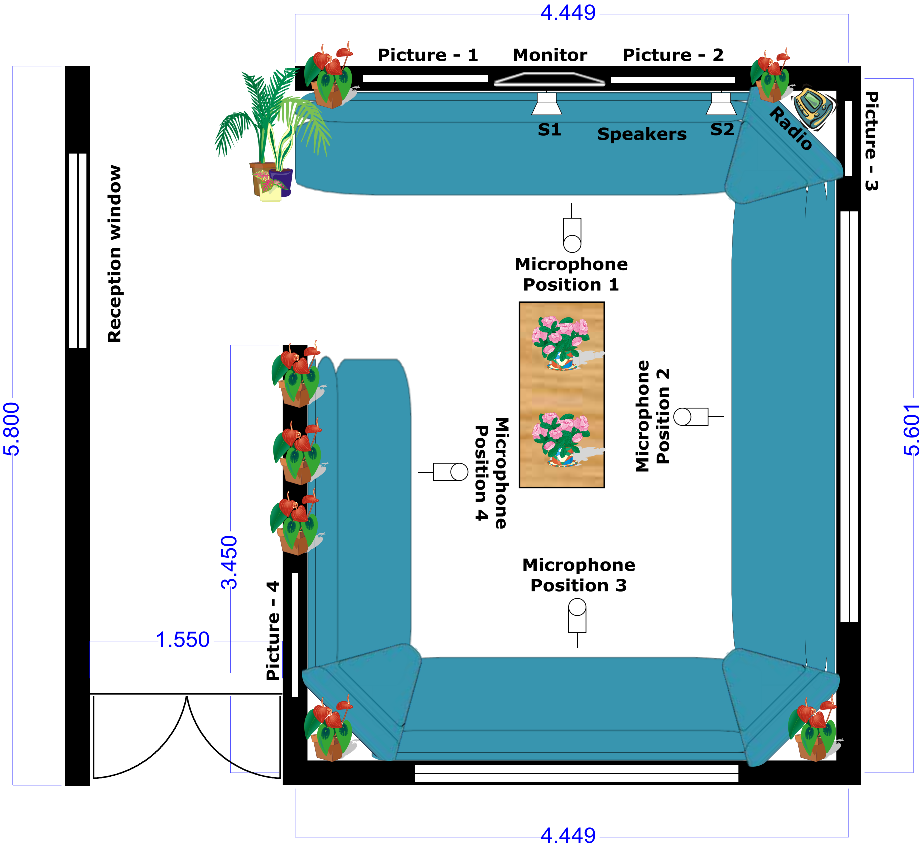

Figure 1: Plan view of waiting room

2.2 Treatment applied

The following are the adjustments that were made to the room.

Auditory factors: Reduction of disturbance from loud conversations and mobile phone use by posting prominent notices on a low table in the middle of the waiting room and reception counter indicating “Quiet zone”.

Introduction of natural sounds such as water sounds. Earlier work has demonstrated that this should be as natural as possible [16] and a low level but audible. Good examples would be recordings of a babbling brook or of waves breaking on a beach rather than high powered fountain noise or water falling in to a culvert, so the effect is subtle throughout the space. It was decided to use the sound of sea waves on a beach and to facilitate the choice of 12 recordings taken around the coast of Britain (available from the British Library [17], these stimuli were evaluated by 14 volunteers. After a practice session the participants rated the tranquility of each recording on a 0 to 10 scale of tranquillity. It was found that the differences between sounds were highly significant ($F=13.66$, $p<0.0001$). The recording considered on average as most tranquil was the sound described as “gentle waves on sand and shingle”, and was the one chosen for the study. This was replayed under the “adjusted” condition through speakers indicated in Figure 1 spaced to be heard throughout the waiting room. This sound replaced the radio station (“Pulse”) playing popular music under the “as is” condition. The comparison of typical sound signals is presented in Figure 2 which include time histories and spectrograms. The sounds produced from the waves on sand and shingle are showing a well defined modulation with an average period of approximately 3 sec and containing higher frequency components compared to the sound of Pulse radio station.

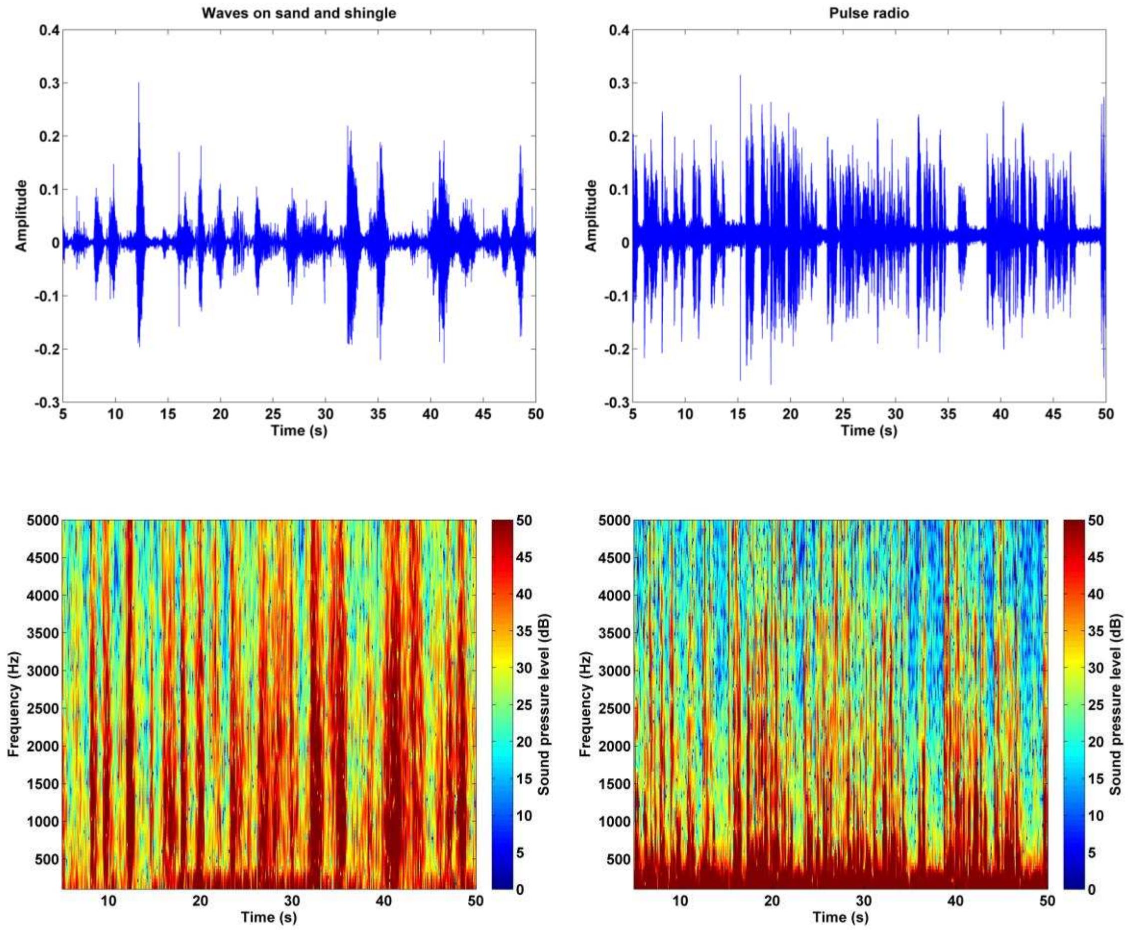

Figure 2: Comparison of the sound signals recorded at P3

Visual aspects: Changes were made to the visual aspects of the design by introducing large photographs of natural landscapes that completely covered the 4 noticeboards that had previously contained health related posters and leaflets. Twenty high quality natural images of landscapes and seascapes considered tranquil were purchased from the internet [18]. These were then shown to 46 volunteers who were asked to rank them in terms of tranquility. The differences between images were highly significant ($F=8.90$, $p<0.0001$). The 4 most highly ranked pictures were then used to prepare large high quality photographs to cover the noticeboards. Figure 3 shows three of the notice boards before and after the changes were made. Two scenes showed coastal views, one looking across a lake and the fourth showed daffodils in a park with tree blossoms.

(a) (b)

Figure 3: Comparison of the room in (a) “As is” and (b)“Adjusted” conditions

The chosen views contained no obvious buildings, infrastructure or people, thus allowing natural elements, such as of water, rock, sand and vegetation to completely dominate each scene. In addition to these natural images fresh flowers (potted Chrysanthemums) were placed on ledges and the central table. Under both conditions the view through the windows was through vertical blinds and this was not altered. Some areas of grass and sky were visible as well as a small area of trees in the background.

2.3 Experimental design

The methodology was to introduce these changes sequentially and for each treatment a questionnaire survey of patients was carried out in the waiting room. The proposed design allowed two basic designs to be considered. They were:

Week 1: “as is” – this is the room as found prior to any treatments

Week 2: With visual and acoustic adjustments termed “adjusted”

Week 3: “as is” - reverse all adjustments

Two “as is” assessments were included to enable a repeated measures design to be employed.

The two basic designs comprised:

(i) Matched pairs where participants under each condition were matched on age and gender.

(ii) Repeated measures where participants recruited on their first visit to the Centre agreed to return on other days to complete the questionnaire under each condition but where in each case they were not booked for a medical appointment.

For those agreeing to return as required a £20 food voucher was on offer on successful completion.

2.4 Analysis

Using the two experimental designs we can arrive at two estimates of the benefits of the "adjusted" room over the "as is" condition.

(i) Matched pairs

Comparing anxiety levels under the two conditions during consultations we can estimate benefits by taking into account initial anxiety levels i.e. the difference between rated anxiety levels of "adjusted" over "as is". However, because two separate groups of participants were involved their susceptibility to stress may have been different and so there is the possibility of sampling bias in the calculated benefit. The expectation was that this would be largely overcome by using a relatively large number of participants under each condition (81 persons)

(ii) Repeated measures

In this case the benefit can be estimated from using each participant as his or her control. Obviously the benefits when visiting to consult with doctor/nurse are not being assessed but we might reasonably assume an additive model of anxiety [19] such that the additional stress of consultation is eliminated when calculating the difference in anxiety levels under the two conditions "as is" and "adjusted".

2.5 Questionnaire

The questionnaire was chiefly designed to measure anxiety levels and to obtain ratings of perceived tranquility.

The full details of the questionnaire will be given elsewhere but the following are the questions which will be the focus of this paper:

Does this room “help you relax”, ”cause you stress” or “has neither effect”?________

Rate how anxious you are NOW by choosing a number between 0 and 10 where 0 is “least anxious” and 10 is “most anxious” ____

Estimate how anxious you were on average yesterday using the same scale:______

Least anxious *Most anxious*

0	1	2	3	4	5	6	7	8	9	10

Then later in the questionnaire:

Rate the tranquillity of this room by choosing a number between 0 to 10 where 0 is “least tranquil ” and 10 is “most tranquil” ______

Least tranquil *Most tranquil*

0	1	2	3	4	5	6	7	8	9	10

3. RESULTS

3.1 A weighted levels

Table 1 tabulates typical L_{Aeq} measured over 60 s measured under each condition for 4 positions in the waiting room shown in Figure 1.

Table 1: Sampled $L_{Aeq,1min}$ in waiting room

Condition	P1	P2	P3	P4
"As is"	47.5	51.1	49.5	51.6
	48.9	52.1	49.3	44.9
	48.1	47.5	49.3	48.8
"Adjusted"	41.1	42.2	41.8	42.2
	42.8	41.1	42.3	40.6
	40.8	41.4	42.2	41.2

The frequency content of typical recordings under each condition opposite the speaker(s) P3 is shown in Figure 4. It can be seen that with the radio playing ("as is" condition) then the frequency content at mid frequencies is considerably higher than with the water sounds. The level averaged over 4 positions in the "as is" condition was 49.1 dB(A) while under the "adjusted condition" it was 41.6 dB(A) i.e.7.5 dB(A) lower. Average background level without radio playing or water sounds was 41.1 dB(A) i.e. slightly below that recorded for the water sounds though individual waves breaking were clearly audible throughout the room.

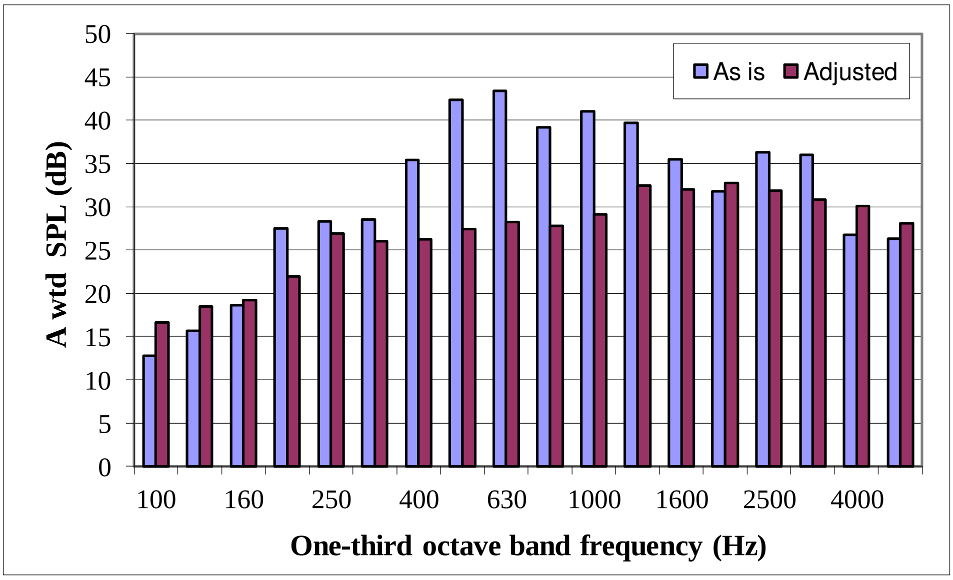

Figure 4: Typical spectra under each condition

3.2 Questionnaire results

81 questionnaires were completed under each condition. The samples under the two conditions were well matched as the average ages were 26.9 yrs and 24.8 yrs for “as is” and “adjusted” conditions respectively and the percentage of female patients was 56.3% under each condition.

The effect of the room condition had some tendencies to alter the effects on relaxation in the expected direction though the trend was not statistically significant. Figure 5 shows the frequency of responses under each condition.

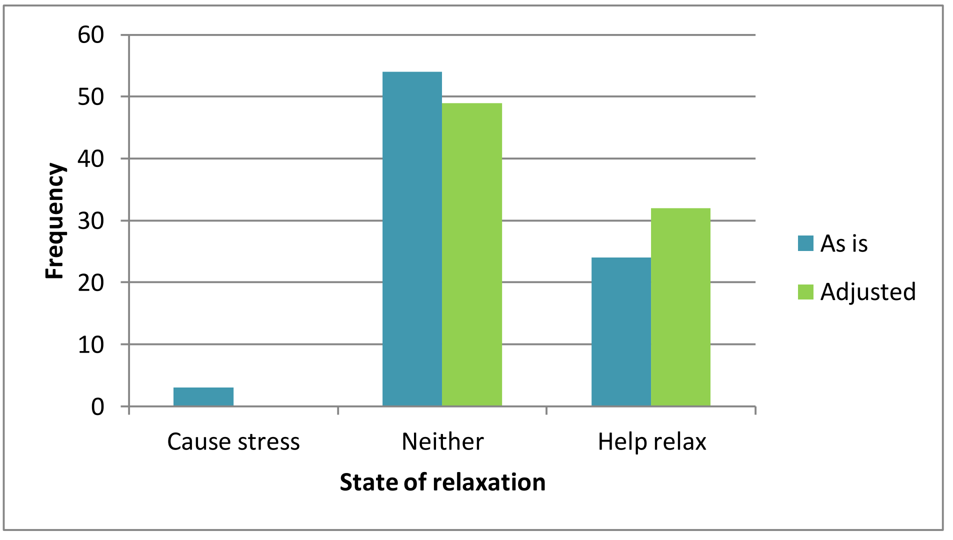

Figure 5: State of relaxation

The changes in anxiety scores under the 2 conditions are given in Figure 6 below. A negative score indicates that there is a reduction in anxiety in the surgery waiting room compared with that experienced at home. Under both conditions it can be seen that generally there are only small shifts in anxiety levels. The mean reduction in anxiety was a little larger under the adjusted condition (0.61) compared with (0.25) under the “as is” condition. Testing the mean values there was no significant difference (t=1.00, p=0.159 – one tail test)

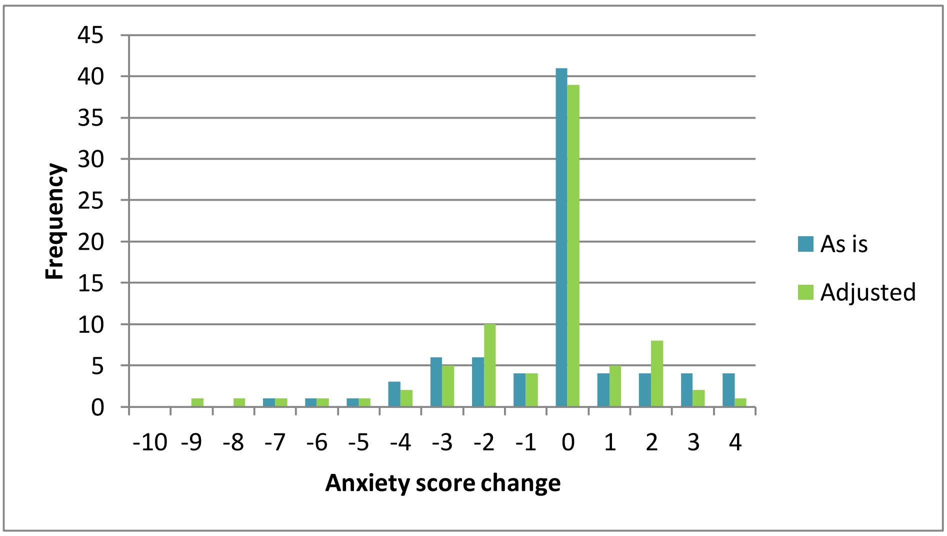

Figure 6: Change in anxiety scores under two conditions

For the seven participants who made assessments under both conditions there was a larger difference. The mean reduction in anxiety level under the "as is" condition was -1.14 whereas under the "adjusted condition" it was -2.14. This difference was statistically significant (t=3.24, p=0.009 – 1 tail test).

For the question concerning tranquillity level it was observed that there were much larger differences. Figure 7 shows the distribution of scores.

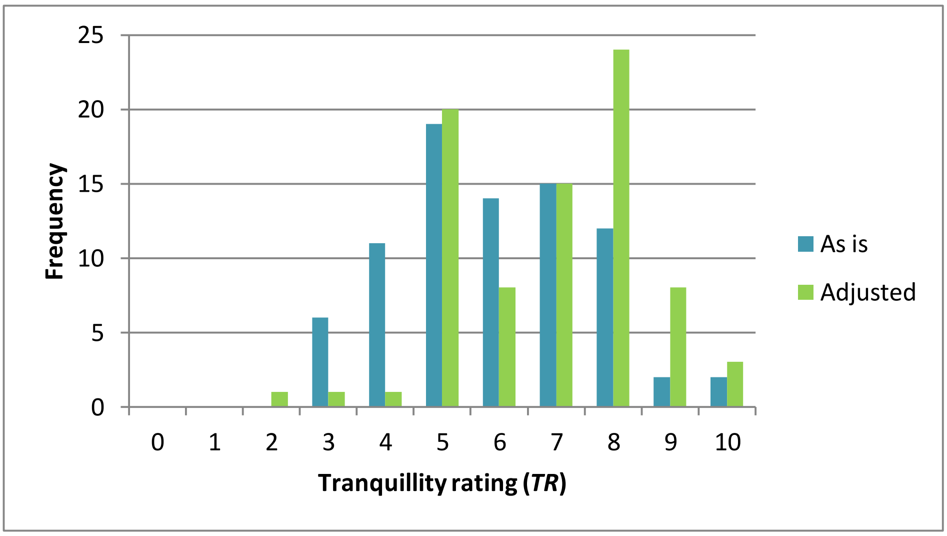

Figure 7: Tranquillity scores

The average rating under "as is" was 5.90 and this rose to 6.85 under the "adjusted" condition. This difference was statistically significant ($t=3.58$, $p=0.0002$). A noticeable feature was the large increase in high scores under the "adjusted" condition. For example, the percentage of scores >7 rose from 19.8% to 43.2% and a corresponding reduction in low scores (<5) from 21.0% to 3.7%.

Again for the seven participants who made assessments under both conditions the differences were greater. Under the "as is" condition the mean score was 5.57 and under the "adjusted" it was 8.86. This is much higher than 6.85 recorded for the matched sample survey. The difference was statistically significant ($t=3.16$, $p=0.0098$)

3.3 Predicted changes in tranquility rating

Predictions of the tranquility rating TR were made using Tranquillity Rating Prediction Tool, TRAPT [8] using equation (1) both under "as is" condition and "adjusted" conditions.

$$TR = 10.55 + 0.041\,NCF - 0.146\,L_{day} + MF \tag{1}$$

Where TR is the tranquility rating on a 0 to 10 rating scales. NCF is the percentage of natural and contextual features and L_{day} is the equivalent constant A-weighted level during daytime (e.g. from 7am to 7pm) from man-made noise sources. The behaviour of this equation has been studied by examining trends in TR with L_{day} at different levels of NCF [9]. It was noted that at the extremes of L_{day} where TR becomes greater than 10 or less than 0 then TR values are set to 0 and 10 respectively. Where no man-made noise is perceptible a default value of 26 dB(A) is given for L_{day} so that when combined with a NCF value of 100% (completely natural scene) then TR is at the maximum value of 10. MF is a moderating factor that was added to the equation following an earlier study [20], and is designed to take account of the presence of litter and graffiti that would depress the rating, or natural water sounds that would improve it. This minor adjustment is designed to take account of the actual environmental conditions at the time of assessment and is unlikely to influence the calculated TR by more than ±1 scale point.

Table 2 gives the predicted values of TR under each condition. It can be seen that the absolute values of TR under the two conditions “as is” and “adjusted” (3.68 and 5.23) are significantly lower than those given by respondents of the matched samples (5.90 and 6.85) and for repeated measures (5.57 and 8.86) respectively. This is considered to be due to the fact that the TRAPT equation (1) was developed using a sample of outdoor landscapes. For indoor spaces respondents are adapted to much lower levels of natural features and consequently the predictions are likely to be too low. Further work using a range of relevant indoor environments would be needed to produce an adequate tranquility rating prediction equation. That said it is interesting to examine the predicted and reported increases in TR following the adjustment to the room. From Table 2 the predicted change is 1.56 while for the matched samples it is 0.95 and for the repeated measures sample of respondents it was 3.29.

Table 2: Predicted tranquility rating (TR) under each condition

Condition	Average man-made noise L_{Aeq}	Percentage of natural features NCF	Predicticted tranquility rating TR
“As”	49.1	7.0	3.68
“Adjusted”	41.1	16.6	5.23

4. DISCUSSION AND CONCLUSIONS

The results indicate that the adjusted room has had a number of effects on anxiety levels and rated tranquillity. Among the most positive effects was the rise in the average rating of tranquility from an average score of 5.9 to 6.9. There was also a marked increase in the percentage of scores >7 which rose from 20% to 43%. There was a tendency for the reduction in anxiety scores to be greater in the adjusted room though this did not reach significance for the matched groups. For the repeated measures group the difference was significant representing a 1 scale point reduction. The smaller effect noted on the anxiety scale may partly reflect the difficulty in obtaining a reliable measure as patient anxiety level is influenced by a wide range of factors including experiences they had before arriving at the surgery e.g. the stress involved in arriving on time that had been reported numerous times during interviews. If the question had involved asking about their mental state of tranquillity then it is likely results would have inversely correlated with those on the anxiety scale as some researchers have found [21]. Here we are attempting to gauge the influence of the room to induce tranquillity so in that sense it is a constant external environmental quality rather than an internal mental state subject to fluctuations.

The impact on the state of relaxation afforded by the room was not significant though there was a tendency for more participants to say they were more relaxed in the adjusted room. As for anxiety the state of relaxation may be influenced by many factors that cannot be controlled in a survey such as this. It should be noted that music in the "as is" condition may have been problematic because of the wide range in personal tastes in different styles. Music has a role to play in well being [22] but personal choice is clearly an important factor in the benefits that can be expected. In contrast natural sounds are generally regarded as positive and especially water sounds as noted above in section 2.2.

Notice boards containing medical leaflets may also pose a problem by focusing attention on real or imagined illnesses. However, a balance needs to be struck between the need to inform patients and the need to create a restorative environment where anxiety levels are as low as possible in the circumstances.

The absolute level of predicted tranquillity TR in the adjusted room of 5.23 is "just acceptable" according to surveys conducted in outdoor spaces though the rating under the "as is" condition of 3.68 would be considered "unacceptable". Although the absolute levels of tranquility rating TR were lower than reported in this study the increase in TR following the adjustments were within the range of results obtained from the respondents in this study. It is clear the TRAPT would need to be adjusted to allow more accurate predictions for indoor spaces. This will be considered in further extensions of the work.

It is concluded that the changes were beneficial but not necessarily optimal and further attention to the soundscape may be required. There would also be gains from considering the visual aspects e.g. using floor to ceiling murals of natural landscapes rather than using pictures with limited areas in order to substantially increase the value of NCF which even after the change was only at 16.6%. For example, increasing the value of NCF to 50% would increase TR to 6.6 which is considered as "fairly good" for outdoor spaces. An example of such a mural is in a café area at the Royal Free hospital in London where there is a floor to ceiling mural of a local pond on Hampstead Heath (see Figure 8). Interestingly seating has been provided facing the mural and it is likely that this placement has a part to play in producing the beneficial impact.

Figure 8: Floor to ceiling mural at Royal Free Hospital café

ACKNOWLEDGEMENTS

The assistance and co-operation of all those working at the Bradford Student Health Centre is gratefully acknowledged and in particular the Practice Manager, Elaine Shaw. The work was funded by the Bradford Centre for Sustainable Environments, University of Bradford.

REFERENCES

[1] Ulrich RS. View through a window may influence recovery from surgery. Science: 1984:224:420-421.

[2] Ulrich RS, Simons RF, Losito BD, Fiorito E, Miles MA, Zelson M. Stress recovery during exposure to natural and urban environments. J Environ Psychol. 1991;11:201–30.

[3] Takano T, Nakamura K, Watanabe M. Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces. J Epidemiol Commun Health 2002;56:913–8.

[4] Grahn P, Stigsdotter UA. Landscape planning and stress. Urban Forest Urban Greening 2003;2:001–18.

[5] Lechtzin N, Busse AM, Smith MT, Grossman S, Nesbit S, Diette GB. A randomized trial of nature scenery and sounds versus urban scenery and sounds to reduce pain in adults undergoing bone marrow aspirate and biopsy. J Altern Complem Med 2010;16(9):965–72.

[6] Hunter MD, Eickhoff SB, Pheasant RJ, Douglas MJ, Watts GR, Farrow TFD, et al.The state of tranquility: subjective perception is shaped by contextual modulation of auditory connectivity. Neuroimage 2010;53(2):611–8.

[7] Sternberg EM. Healing spaces - the science of place and well-being. Havard University Press:2009.

[8] Pheasant RJ, Horoshenkov KV, Watts GR. Tranquillity rating prediction tool (TRAPT). Acoust Bulletin 2010;35(6):18–24.

[9] Watts GR, Pheasant RJ and Horoshenkov KV, Predicting perceived tranquillity in urban parks and open space, Environment and Planning B: planning and design. 2011:38 (4):585-594.

[10] Watts GR, Miah A, Pheasant RJ. Tranquillity and soundscapes in urban green spaces - predicted and actual assessments from a questionnaire survey. Environment and Planning B: Planning and Design: 2013:40(1):170–82.

[11] Watts GR and Pheasant RJ, Factors affecting tranquillity in the countryside. Applied Acoustics:2013: 74(9):1094-1103.

[12] Pheasant RJ and Watts GR, Towards predicting wildness in the United Kingdom, Landscape and Urban Planning: 2015: 133: 87-97.

[13] Department of Health. Specialist services, Health Technical Memorandum, 08-01: Acoustics. 2013. At:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/144248/HTM_08-01.pdf

[14] Orellana D, Busch-Vishniac IJ and West JE. Noise in the adult emergency department of Johns Hopkins Hospital, J. Acoust. Soc. Am. 121, 1996 (2007); http://dx.doi.org/10.1121/1.2642309

[15] Mackrill J, Cain R and Jennings P. Experiencing the hospital ward soundscape: Towards a model
Journal of Environmental Psychology, Volume 36, December 2013, Pages 1–8

[16] Watts GR, Horoshenkov KV, Pheasant RJ, Ragonesi L. Measurement and subjective assessment of

water generated sounds. Acta Acust Acust 2009;95:1032–9.:

[17] British Library, “Waves, The sounds of Britain’s shores”, 2011

[18] www.shutterstock.com

[19] Zohar, D. An additive model of test anxiety: role of exam-specific expectations, Journal of Educational Psychology. 90(2), 1998, 330-340

[20] Watts GR, Pheasant RG, Horoshenkov KV, Validation of tranquillity rating method, CD-ROM, in: Proceedings of the Institute of Acoustics and Belgium Acoustical Society, Noise in the Built Environment, Ghent, April 2010.

[21] Ellisona CG, Burdetteb AM and Hill TD. Blessed assurance: Religion, anxiety, and tranquility among US adults. Social Science Research, 38(3), September 2009, 656–667

[22] Batt-Rawden KB, DeNora T and Ruud E. Music listening and empowerment in health promotion: a study of the role and significance of music in everyday life of the long-term ill. Nordic Journal of Music Therapy, 14(2),120-136, 2005

Table legends

Table 1: Table 1: Sampled $L_{Aeq,1min}$ in waiting room

Table 2: Predicted tranquillity rating (TR) under each condition

Figure legends

Figure 1: Plan view of waiting room

Figure 2: Comparison of the sound signals recorded at P3

Figure 3: Comparison of the room in (a) “As is” and (b) “Adjusted” conditions

Figure 4: Typical spectra under each condition

Figure 5: State of relaxation

Figure 6: Change in anxiety scores under two conditions

Figure 7: Tranquillity scores

Figure 8: Floor to ceiling mural at Royal Free Hospital café