A Preliminary Soundscape Management Model for Added Sound in Public Spaces to Discourage Anti-social and Support Pro-social Effects on Public Behaviour

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Introduction

In *The Music of the Environment* [1] R Murray Schafer gives examples of good and bad acoustic design and the way these might affect people's moods or potentially act as a 'harmonising influence'. Building upon these ideas, researchers have begun to explore the potential of soundscape management to have a profound impact on the sorts of behaviour observed in these environments. This project's initial experiment explored the positive effects of soundscapes on crowd behaviour [2]. The case study called 'West Street Story' was a night-noise intervention pilot. It tested a 3D outdoor ambient sound installation and what effect this might have on levels of anti-social behaviour and sense of security. Police feedback from the event confirmed how much 'quieter' the area was than normal, to the extent that they were confident enough to redeploy forces elsewhere in the city. Building upon these findings, a more scientifically controlled investigation of similar themes was conducted - in a pedestrian subway (i.e. an underground passageway for pedestrians) referred to as 'The Tunnel' – to enable a better evidenced measure of soundscape's safety potential using non-intrusive and non-selective surveillance techniques, and focusing on more objective measures including walking speed [3] and loitering (interest in surroundings) [10]. Though more restricted in conclusory scope, such measures can potentially be used in combination with other metrics to help infer more general prevailing psychological states and thus act as a foundation for broader measures of the subjective sense of security and safety amongst the general public. The goal is to develop a model for the management of such added sounds within a broader soundscape management and urban design framework; therefore, in addition to more scientifically controlled body language analysis, in this experiment the Tunnel was also characterized, from the acoustic viewpoint.

The Acoustic Characterisation of the Tunnel

The West Street tunnel connects the seaside with West Street. It has a L shape with a main leg of approxiamtely 30 m, which splits into two parallel branches in the last 9 m towards the junction, and a secondary leg of approxiamtely 10 m towards the city centre. The acoustics of long enclosures have been thoroughly investigated, and it has been proven that conventional room acoustics models for sound level distributions and reverberation time calculations do not always apply to such spaces [4]. Therefore, both a sound propagation simulation and an on-site measurements study were carried out to characterise acoustically the tunnel. A 3D model of the tunnel was prepared and imported in the I-Simpa software (http://i-simpa.ifsttar.fr/) for calculation. Two omnidirectional sources were located in the model where the actual loudspeakers in the tunnel are. A sound propagation simulation was performed considering a sound power of 100 dB for each sound source (i.e. loudspeaker). Figure 1 shows that for the main leg (red region to the right of the image) the sound field is nearly a diffuse field with some local level increase close to where the tunnel splits, while the level dramatically drops in the two branches.

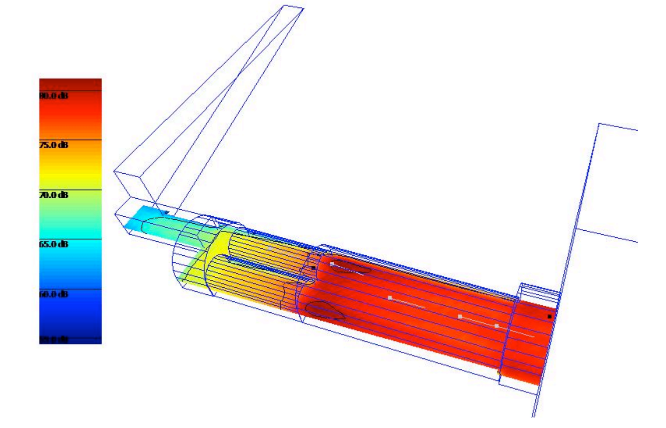

Figure 1: Map of sound-pressure level distribution in the tunnel using two omnidirectional sources of 100 dB each.

Reverberation time (RT30) measurements were performed on-site, in accordance with ISO 3382-2:2008 [5], considering two sound sources' positions and seven point receivers at five-meter distance intervals from the seaside end (0 m) to the inner branches (30 m). Figure 2 shows that, at low frequencies, mean RTs exceed 3.5 s, and at higher frequencies they range between 2 and 3 s. Furthermore, RTs greatly change as a function of the position within the tunnel. In order to provide further insights on the acoustic environment of the tunnel, the background noise entering the tunnel from the seaside end was also measured with a reference microphone at the seaside end and six microphones located at five-meter distance intervals from the first one. Figure 3 shows the background noise attenuation within the Tunnel, as a function of distance from the seaside end. Overall, the on-site measurements showed that the acoustic environment in the Tunnel is highly reverberant, and reverberation varies greatly as a function of both frequency and position within the space. Sound level attenuation from the seaside end is limited and becomes more significant where the tunnel splits. All such factors are likely to affect the sounds heard in the tunnel in a way that they might be perceived as *distorted* or *unfamiliar,* thus affecting the general feeling of perceived safety [6].

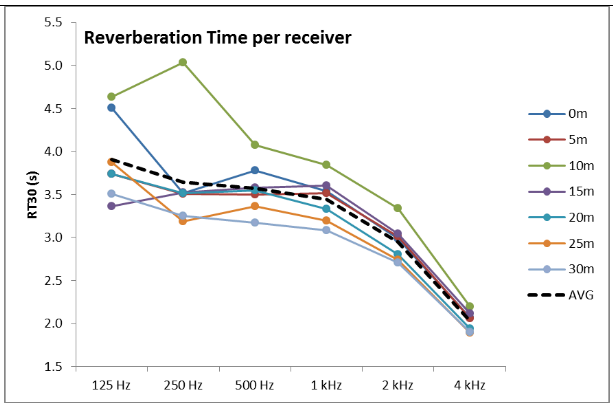

Figure 2: Reverberation times as a function of frequency, for the different point receivers, from the seaside end (0 m) to the inner branches (30 m).

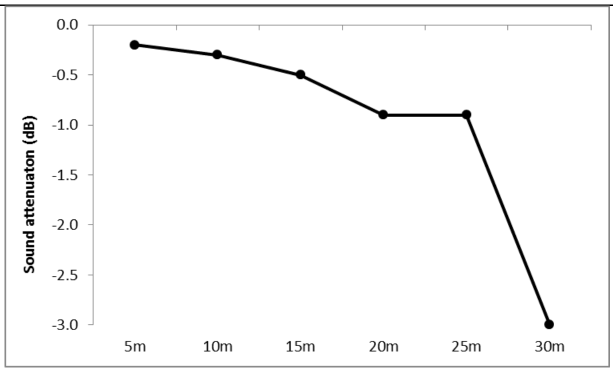

Figure 3: Sound attenuation for the different point receivers, from the seaside end (0 m) to the inner branches (30 m).

Materials and Methods for the Experiment

A music reproduction system with water-resistant specifications was installed into the tunnel, as were three video surveillance cameras and a digital video recorder (Figure 4) [10]. Concurrently, large colour photographic posters depicting Brighton landmarks were installed as decorations. The music interventions were played between the hours of 7 PM and 7 AM on Thursday nights, Friday nights, and Saturday nights; for the duration of the pilot study, the Tunnel was left open all night on these nights. Playlists of traditional, archetypal representatives of classical, jazz, and contemporary dance music (and silence) were cycled repeatedly to Tunnel users, most of whom passed through the music intervention in approximately 30 seconds; the music was chosen to be non-aversive; the level that it was played at was measured to have a specific L_{Aeq} of 68-81 dB. The Tunnel runs from the Beach Promenade to the northwest corner of the King's Road intersection with West Street. (Figure 4). The North-South leg of the Tunnel is approximately 30 meters in length, and varies in width between 9 meters and 2.33 meters (Figure 4). Along the floor white stripes made of durable duck tape were installed, occurring every 210 cm to allow for the calculation of the speeds of people moving along the Tunnel (Figure 5) [3]. Data was gathered with the approval of the local university ethics committee. According to the British Sociological Association's Statement of Ethical Practice (2004, p.4) [7], "The use of covert methods may be justified in certain circumstances. For example, difficulties arise when research participants change their behaviour because they know they are being studied." By the requirement of The British Psychological Society's *Code of Human Research Ethics* (p. 24, 2010) [8], the Tunnel project upholds that 'covert collection of data should only take place where it is essential to achieve the research results required, where the research objective has strong scientific merit and where there is an appropriate risk management and harm alleviation strategy.' The Tunnel project is a non-participant, covert observation study. It was essential during this project that informed consent was not sought from the passers-by. The subconscious and spontaneous responses that the Tunnel project aims to understand and analyse would be impossible to elicit if the passers-by were asked to provide informed consent. The music selected for the interventions in the Tunnel were chosen based on several criteria relative to the acoustic character of the Tunnel; it had to be: 1) **inclusive**: ensuring divergent genres were included in each playlist; 2) **non-aversive**: not played at loud volumes or too displeasing (e.g. atonal music); 3) **sound good in the highly reverberant Tunnel**: e.g. music that had a **narrow dynamic range**; clear and simple melodies; notes/timbres with a **wide frequency spectrum**; notes with **strong attack / peaks**. To ensure we could test for entrainment of walking the music also had to: have **a clear beat throughout**; be in **2/4 or 4/4 time signature**.

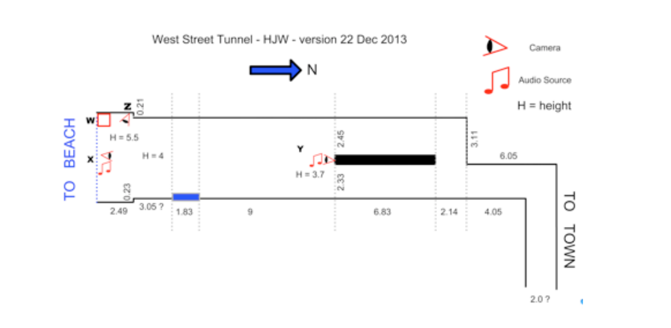

Figure 4. Schematic of West Street Tunnel showing physical dimentions and location of the music intervention system. [10]

Behavioural Observations in the Tunnel

In order to pursue the overarching aim of determining music's consistent effects on behaviour, with a view to revealing its potential to encourage more pro-social activities, we tested for and analysed two body language metrics in response to changes in the acoustic environment: I) pedestrian walking rates and II) loitering.

I) Analysis of pedestrian walking rates. To test the effect that music could have on the speed of people walking through the Tunnel walking velocity in silent conditions were compared against velocity in the presence of background music and the effect that fast and slow tempo music had upon this variable. Computer vision and video analysis techniques were deployed to automate the quantification of both walking rates and entrainment (based on the up-down bobbing of the head and the left-right swaying of the shoulders) [3]. Films with the appropriate music were observed and the precise frame numbers where people crossed white lines were recalculated as velocity rates based on the fact that we knew the distance between the lines and that our frame capture rate was 24 frames per second.

Figure 5. Example of motion tracking of a person walking in the Tunnel (López-Méndez et al, 2014) using a tracking algorithm for testing entrainment to rhythm. [3]

Preliminary results found that firstly, when contemporary instrumental electronica/dance music (Cirrus) was deployed, people's walking velocity through the Tunnel was slower (mean = 1.23 m/sec, n = 105) than in the absence of music (Figure 6, mean = 1.44 m/sec, n = 22, unpaired T-test: $P < 0.0001$). Reference values from the scientific literature suggest healthy men in their twenties are thought to walk comfortably at 1.393 m/sec, while women in their twenties walk at 1.407 cm/sec [9]. This suggests that, based on the measurement techniques employed on the multi-aged Tunnel cohort, during silence the passers-by walked at almost exactly the scientific reference rate; however, when listening to Cirrus people walked significantly slower than normal (Figure 6) [10]. These conclusions are intriguing in view of [11], which investigated the effects of ambient/background music on shopper behaviour. The difference observed in walking speed between high and low tempo music is in agreement with Milliman's findings; however, whereas Milliman found higher tempo music was associated with higher customer velocity than no music, we found that both higher and lower tempo music decreased walking velocity through the tunnel. This divergence might either be ascribed to Milliman's more extreme tempo variations or our stricter controls for tempo, eliminating style and (other) variables, or alternately it may suggest that music's behavioural effects are highly context sensitive [12]. Furthermore, this general decrease in the speed of those walking through the tunnel when music was deployed might reflect a greater sense of security, and thus is a preliminary indicator of the soundscape's potential to support safer environments [12].

II) Analysis of loitering rates. Loitering was characterized in territorial terms, as a phenomenon whereby individuals will remain in the Tunnel for prolonged periods of time, displaying behaviours which advance ownership claims over its attractive territorial affordances. These territorial behaviours are often perceived as exclusive or defensive in nature, discouraging other members of the public from entering what they perceive as someone else's territory, or causing feelings of discomfort while passing through such a region. In order to measure loitering, the video data was captured over two consecutive Saturdays when the music intervention was active (between the hours 00:00-07:00 and 19:00-24:00). [10] The experimental setup, including motion-activated video recording, enabled selective recording of the entire set of people travelling through the Tunnel during this time period (a set of n = 559 films, each having a minimum of one person moving in the tunnel). From this initial set, we looked exclusively at films of file-size > 6 megabytes (n = 114), thus filtering out those films showing activity in the Tunnel for less than 60 seconds. Loitering was defined in this instance as prolonged lingering in the Tunnel for longer than 60 seconds, and our analysis found surprisingly little evidence of it, with only 16 instances of either individual or group loitering being detected across the two 12-hour periods. Loitering would most commonly occur in groups (of size 2-11), with an average group size of 3 people. This equated to a total of 49 individuals detected loitering, much less than anticipated for a regular weekend period.

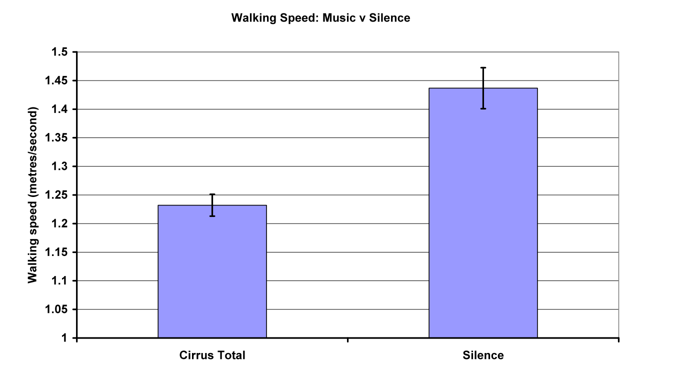

Figure 6. Difference in walking speed during music and silence in the West Street Tunnel experiment. [10]

As a surrogate measure of whether music might deter or encourage loitering, it was considered whether loitering instances began or ended on a particular piece of music, based on the assumption [13] that if people's motivations for remaining in the Tunnel are on the borderline between wanting to stay or to go, the influence of a piece of music that they find counter-territorial will be enough to initiate a movement to leave during that piece of music. In this case the classical (Handel) and Jazz music excerpts were associated with the beginning (entry) of fewer loitering episodes than would be expected by random chance, and likewise the classical music was associated with more exits than expected if these events had occurred randomly with respect to the music. (Figure 7) [10]. This data suggests that, compared to the other music, classical music in this context

	% Playlist	Enter During	Expected	Exit During	Expected
Classical	18.7%	1	3.00	5	3.00
Jazz	28.1%	3	4.50	3	4.50
Ambient/Dance	39.1%	8	6.25	5	6.25
Silence	14.1%	4	2.25	3	2.25
TOTAL	100.0%	16	16.00	16	16.00

Figure 7. Comparison of actual loitering events to expected loitering events if the events were randomly distributed without reference to music. [10]

functions as a loitering deterrent, while silence (over-represented during entry) might be comparatively welcoming for loiterers. While 16 instances is a very small set of loitering episodes to draw inferences from, the results indicate overall a smaller number of loitering instances than expected.

Discussion

Many of the behaviours observed in the Tunnel can be explained with reference to the ability of music (and perception of the soundscape in general) to define social territory and thus to influence the kinds of activity occurring in an environment, through its capacity to prescribe a set of "acceptable" behaviours [13]. It should be noted, however, that the Tunnel is already an environment which is substantially "territorial" in nature, on account of it providing a feeling of seclusion, defensive advantage and protection from above, in the same manner that a burrow might afford strategic survival advantages to a small mammal. Regarding these concerns, it's recognised that the Tunnel is a place where it would be expected to witness extensive "territorial" behaviour, in which context, music is best conceived as a means to mediate rather that wholly exclude such activities. These preliminary conclusions, while provocative, are thus suggestive of the promising scope of future analysis. Such results suggest a soundscape approach can be valuable in helping mitigate anti-social behaviour; however, the results also pose a number of additional questions and advocate more detailed investigations into soundscape management in real-world environments. It is expected that, beyond the cultural meanings associated with different music excerpts, there will be associations between the physical features of sounds (i.e. psychoacoustical and musical metrics) and perception, and subsequently the use of space.

Conclusions and Future Work

Further observation of music's effect on territorial use of space in the Tunnel will be useful for determining soundscape's capacity to promote inclusive territory. While the results have focused on providing a foundation for determining soundscape's potential to promote pro-social (versus anti-social) behaviour, the primary way to progress this aim would be to expand upon these "territorial" observations. In addition, automating the analysis of the effect of music tempo upon walking speed and of music's capacity to induce entrainment (moving in time to the music) should enable corroboration and expansion of the initial findings. These experiments demonstrate the fruitfulness of using nonverbal behaviour as assessments (and in some cases metrics) for public behaviour in response to unrequested, ambient/background music soundscape interventions; have demonstrated that it is likely to be possible to measure human biomechanical and velocity measurements from a single frontal aspect camera (slightly elevated, with appropriate distance markers on the floor); showed that in this exposed location, vandalism did not undermine all attempts at scientific measurement; that the affordable equipment installed could withstand the imperfect weather conditions inside the exposed tunnel. Preliminary evidence was found in favour of all the planned hypotheses tested: 1) ambiently-presented music affects people's behaviour, 2) site specific music can discourage loitering while silence (in comparison to music) can encourage loitering, 3) faster music makes people walk faster than slower music, and 4) even brief exposures to music can make people more generous and charitable. Future work will seek and investigate further the relationships between the physical characteristics of the added sounds and the corresponding perceptual outputs, and will try to relate this to other well established models for soundscape appraisal; analysing more data, triangulating the behaviourial results with the acoustics data and using automated processes to more decisively conclude how ambient/background music can have consistent, positive effects on behaviour. If further analysis corroborates these early results, this would be the first large-scale, objective demonstration that ambient/background music leads to predictable changes in people's walking speed.

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