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Technical Note

MP3 listening levels on London underground for music and speech

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ABSTRACT

In the last 10 years the prevalence of the MP3 players has grown exponentially. The use of devices with in-ear earphones under urban conditions has been reported widely in the press anecdotally. This study compared listening levels for 33 test subjects under quiet conditions and that representative of a London Underground train journey. Calibrated and equalised recordings of underground trains running in tunnels were played through a loudspeaker in an anechoic chamber, whilst pop music, rock music or speech were played through in-ear earphones. Whilst the participates listened to the MP3 player, a Binaural Head and Torso simultaneously measured the noise levels through a second set of identical in-ear earphones. The participants had time to adjust the volume to a comfortable setting on each occasion. Results show very high levels of noise exposure particularly for rock music, 94% of subjects exceeding lower exposure action value within 1 h on an underground train journey. The MP3 player volume setting increased significantly more for speech than for music when underground train noise was introduced.

1. Introduction

The risk of recreational noise exposure such as amplified music played at concerts or in nightclubs has been well documented for over the last 40 years; however noise exposure from other recreational sources such as that from personal stereos has been less documented. The advent of MP3 players with its long battery life and huge memory, has made 'music on the move' inherently popular with millions of people in the UK alone. Due to the meteoric rise of the MP3 player, many recent stories in the press have discussed the increasing use of personal stereos, mainly focusing on the levels at which some people (particularly teenagers) listen to music and the possible health implications. It has been argued that the levels at which people listen to music is a personal choice and that in most cases the majority of people are responsible enough to know what is 'too loud'. However, what if the levels set by the user are strongly influenced by another variable such as background noise? The sight of commuters listening to music is a familiar scene on London Underground, where background levels can sometimes be as high as a busy bar playing amplified music [1]. If a commuter listens to their MP3 player whilst exposed to these levels of background noise, how high will the volume be set to overcome the background noise? More importantly, are these levels a cause for concern with regards to personal health? Bearing in mind that current (2005) UK Noise at Work Regulations set a upper exposure action limit of 85 dB(A) averaged over an 8 h working day, it seems comprehensible that these levels could be exceeded, as has been found for people using personal listening devices whilst exercising [2].

This investigation aimed to measure the output levels of an MP3 player used by 33 test subjects when exposed to a typical continuous background noise under controlled conditions. The output level will be measured with and without a background noise present to enable a comparison to be made with regards to the effect background noise has on the user defined output level. For more information [3,4].

2. Review on noise levels from MP3 players

In February 2006 a lawsuit was filed against Apple Inc. by John Kiel Patterson of Louisiana USA. Although it is not medically proven that the accuser suffers from hearing loss, the prosecution lawyer based the case on the claim that the MP3 player is 'not safe to use as currently sold' as it does not carry 'adequate warnings regarding the likelihood of hearing loss'. The result was software based volume limiter being installed on all types MP3 players. France has legislation for all portable in-ear music devices to be limited to 100 dB(A).

Fligor and Cox [5] carried out an extensive study into the noise levels generated by the headphones of commercially available compact disc players. Using a 'dummy head' microphone configuration, white noise was measured through a range of compact disc players and headphones, these were then compared to noise levels of various music samples played in the same arrangement. This

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enabled the investigators to gain a thorough understanding of the different characteristics of a good range of headphones and compact disc players with respect to noise exposure.

The study found that sound pressure levels (free-field equivalent) measured at the maximum volume setting 'ranged from 91 dBA to 121 dBA'. In some headphone/compact disc player combinations, peak sound pressure levels were measured in excess of 130 dB SPL. The experiment also showed that for a given volume control setting, smaller headphones produced higher levels with the 'in-ear' type headphone giving an increase of 7–9 dB. Findings included setting a player to 70% of maximum gain resulted in an excessive noise dose within 1 h. A duration that Deafness Research UK/BMRB telephone survey of 1001 people found that at least 81% of young people, 16–34, listened to on their iPod [6].

Serra et al. [7] carried out a 4 year study into the sound emission levels exposed to a group of adolescents from discos and personal music players, and the subsequent auditory and psychosocial behavioural effects. The noise levels were measured using noise dose badges (similar to those used in noise at work assessments) fixed to the test subjects whilst they attended their favourite disco venues. In addition, the test subjects were instructed to regularly report to the laboratory where they would have the levels of their personal stereos measured using a B&K 4128 HATS, in an arrangement similar to that described in Section 3.

The investigation found that the test subjects were exposed to levels regularly exceeding 105 $dBL_{Aeq,T}$ when frequenting their chosen discothèque. The maximum L_{Aeq} was measured to be 112.4 dB and the minimum 108.4 dB. Levels produced by the subjects' personal stereos were measured to be between 75 and 105 $dBL_{Aeq,\ T}$. The audiogram measurements taken from the test subjects showed that over the 4 year period, a threshold shift occurred during the third year of project. This was considered to be a 'permanent hearing impairment at an early age'. However, it was noted that the use of personal stereos for each test subject was not significant when compared to the high levels produced in discothèques, where the test subjects typically spent 3–4 h during every visit. This was also the conclusion of Torre [8].

Kahari et al. [9] undertook a study of personal music player users on Stockholm Central Station using a KEMAR. They found that earphones were the preferred listening device, confirming the findings of Torre [8]. The listening levels set by 41 subjects were measured at the station, findings included a free field corrected average noise level of 83 $dBL_{Aeq,60\,s}$, with a large range, 73–102 dB, similar to those found by Serra et al. [7]. The conclusion was that people fall into two groups: casual users who listen at lower levels and people with excessive listening habits that may indeed damage their hearing sensory organ in time.

3. Experimental methodology

3.1. Transportation background noise

People who listen to MP3 players during their commute to work are generally exposed to background noise from trains (underground and overground), busses and road traffic (whilst walking). Many people have a varied commute which may encompass any one of, or a combination of these background noises. Therefore an attempt was made to measure a calibrated sample of background noise from each of these examples using a calibrated B&K 2260 recording to a Sony DAT recorder. This allowed simultaneous monitoring of the noise levels being recorded onto the DAT, with the added bonus of the high quality B&K signal chain. The calibrator was used to record a calibration tone onto the DAT, which would be used during the laboratory experiment to aid the calibration of the recorded background noise. When making the measurements/recordings, the microphone was held at chest height whilst to give typical background noise scenarios of which a commuter would be exposed.

The highest recorded noise levels were found to be on London Underground and hence these were taken as the background noise for the experiment, rather than roadside noise, bus noise or train noise. To gather the full extent of the carriage noise levels on the London metro system a full survey of all lines on all three inner zones of the network were measured [1], see Fig. 1. This map can be easily compared to the illustrative map of London Underground [10]. The noise levels can be broadly banded into overground levels of 68 $dBL_{Aeq,T}$, 75 $dBL_{Aeq,T}$ for the larger cut and cover metro lines, and 85 $dBL_{Aeq,T}$ for the deep subsurface lines. These between station in-carriage noise levels were in agreement with the noise level recordings presented.

3.2. Audio processing

The recordings made of the Underground train were transferred from the DAT to a PC running Adobe Audition audio processing software, which was also used to play back the signal. Here the audio signal recorded on the underground train was inspected in more detail so that a consistent passage of audio could be found, thus cutting out any unwanted 'pops' or 'squeaks' which are often common in any audio recording made in the field. Once a suitable passage of audio was identified, the software was used to loop the section (in this case a 30 s sample) which would be used to represent the noise inside an underground tube train during the experiment. Fig. 2 shows the noise spectrum of the carriage train noise. The reproduced audio train noise signal was played at the representative measured carriage level of 84 $dBL_{Aeq,2\,min}$ with a L_{AFmax} of 96 dB, a level very similar to those found by Gregson [1].

3.3. Measurement methodology

Three 'tracks' were chosen for the experiment. These were two genres of music and one 'news podcast' which included speech only in MP3 format. The genres of music chosen were 'Rock – Skidrow' and 'Pop – Madonna' as these are considered to have varying spectral content, see Fig. 2 for a 1 min spectra analysis of the Adobe Audition files. The MP3 player was set to 85 $dBL_{Aeq,\ 1\,min}$ as measured through the in-ear earphones, using a B&K 4100 HATS connected to a Norsonic 121 analyser in an anechoic chamber, as shown in Fig. 3. Using an anechoic chamber eliminated room

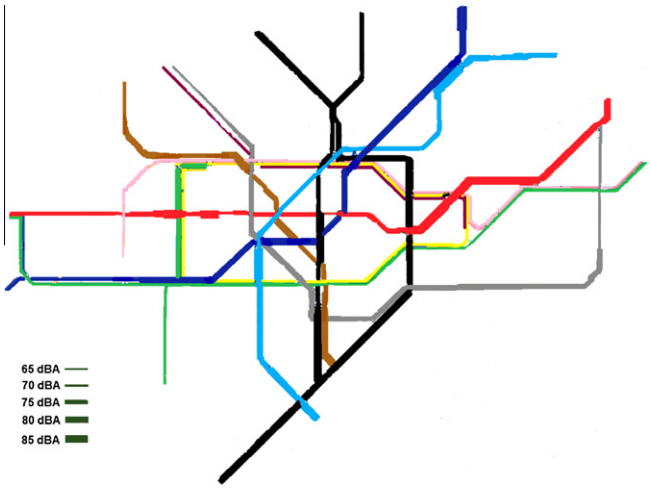

Fig. 1. Noise levels (dBA) measured across a metro transport network on train carriages showing levels from 65 to 85 dBA.