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IPods listening levels on London Underground

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In the last 5 years the prevalence of the iPod/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 recordings of underground trains running in tunnels were played through a loudspeaker in an anechoic chamber, whilst pop music, rock music or speech podcasts were played through the in-ear earphones. Whilst the participates listened to the iPod, a Binaural Head and Torso simultaneously measured the noise levels through a second set of 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, 90% of subjects exceeding lower exposure limit within 1 hour of use, when used on the an underground train. The iPod volume setting changed significantly more for the podcast, 22 dBA than for the music 12 dBA on average.

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 such as Apple's iPod, 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 the London Underground, where background levels can sometimes be as high as a busy bar playing amplified music. 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 maximum exposure limit of 87 dB(A) averaged over an 8 hour working day, it seems comprehensible that these levels could be exceeded. If this is the case, it could be argued that a commuter listening to their Mp3 player during their commute to and from work could be more at risk to hearing damage than a road-worker using a pneumatic drill who, under law, uses appropriate hearing protection.

This investigation aims 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.

Development of MP3 Players

Ever since the arrival of the Sony's 'Walkman', articles have been written in audiology journals speculating the possible damage caused by over exposure to music which is being produced in such close proximity to the ear. However, as discussed previously, hearing damage is generally caused by exposure over time rather than a single event (unless the event is an extremely high level). One of the main factors affecting the use of personal cassette and compact disc players was the lack of media available and the battery life, both controlling factors of the listening time, approximately 30 songs. Mp3 players however, are low power devices which can store up to 40,000 songs and have a typical battery life of 40 hours. It could be argued, therefore, that due to the massive selection of songs (meaning short attention spans can be catered for) and long battery life, the noise exposure for the average user of a modern Mp3 player could be much longer than that of users of personal cassette players. As of June 2007, Apple had reportedly sold 100 million 'iPods', often regarded as the industry standard.

Review of MP3 Noise Levels

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 hearing is pending. For instance, France has legislation for all portable in-ear music devices to be limited to 100 dB(A). Many independent sources claim that devices such as the iPod are capable of producing levels of 115 dB, however whether this is at a particular frequency or an overall L_{Aeq} is unknown.

Of course, not everybody will listen at the maximum volume, but there is a risk of the volume being increased by accident. To address this problem the latest iPod models contain a user defined noise limiter built into the software, allowing the user to pre-set the maximum volume setting.

Listening factors from portable music players has been extensively researched, for a review of the literature see Wash [1]. To highlight two recent results: First, Fligor and Cox [2] found that setting a player to 70% of maximum gain resulted in an excessive noise dose within one hour. Secondly, a telephone survey, undertaken by Deafness Research UK/BMRB, of 1001 people found that 81% of young people, 16-34,listened to an iPod for at least 1 hour per day [3]. p3 player.he deadline of paper submission is May the 7th. Manuscripts sent via email are not accepted.

Experimental Setup

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). It was decided to measure and record the noise on an underground train during a commute. Typical noise levels were 84 $dBL_{Aeq,2min}$, with the highest single event of 96 dBL_{AFmax}. The wave file of the underground train journey was used as the background noise in the following experiment.

Three 'tracks' were chosen for the experiment, Skidrow, Madonna and BBC News. These were two genres of music and one 'news podcast' which included speech only. The genres of music chosen were 'Rock' and 'Pop' as these are considered to have varying spectral content, see Figure 1 for a 1 minute spectra analysis with the iPod set to 85 dBA as measured through the in-ear earphones, using a B&K dummy head and torso connected to a Norsonics 121 analyser, see Figure 2, for the configuration.

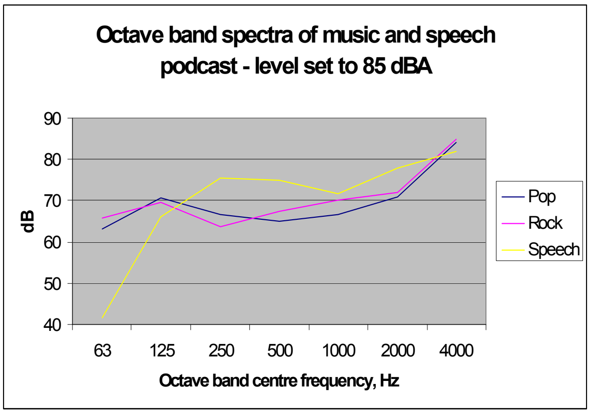


Fig.1 Comparison of measured octave band spectra.

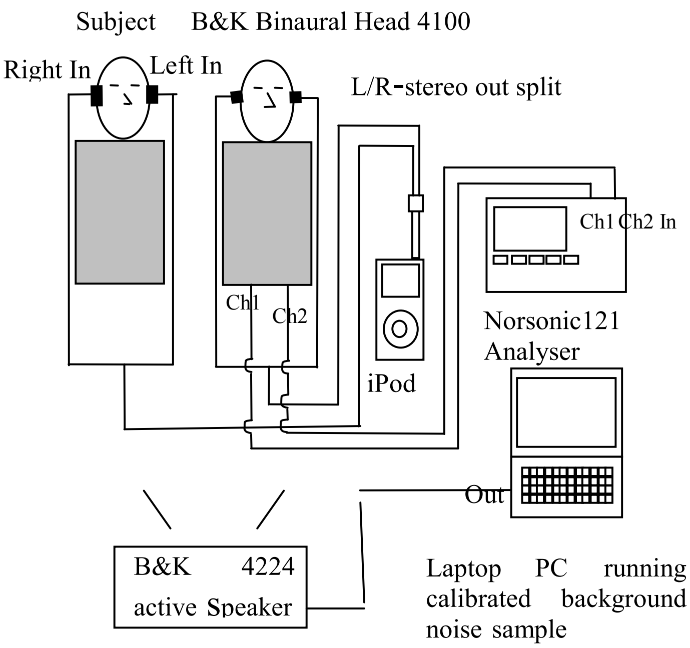
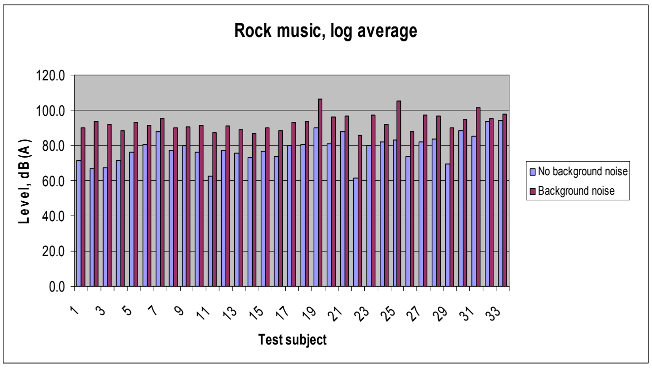


Fig 2. Block diagram of the apparatus setup

Due to space restrictions, only Rock and Speech results are presented. Each 'track' was played through the in-ear earphones and the volume adjusted by the test subject until he/she was happy with the level. Then Norsonic 121 noise analyzer was activated to simultaneously measure the noise levels via the dummy head. This was achieved using a signal splitter at the output jack of the Mp3 player, meaning the stereo signal was being played through two sets of in-ear earphones. The noise levels were measured over a period of 20 seconds for each of the tracks. This was then repeated with the calibrated background recording of the underground train played through the loudspeaker at 84 dBA in the anechoic chamber. Of the 33 subjects, 66% were <40 years old, 13% over 60 and 21 % middle aged.

Measurement Results

Presented are listening levels for 33 subjects without noise and with background noise, Fig 3 and 4.



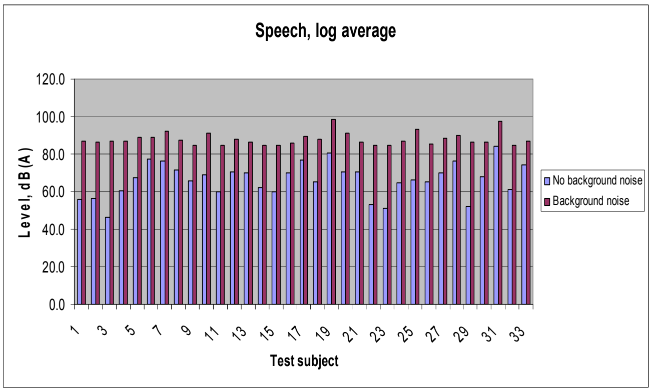


Fig 3 and 4. Measured $L_{Aeq,20sec}$ from iPod for each subject

For rock music, the lowest measured level was 61.5 dBA and the highest was 94.4 dB(A). The mean level has been calculated to be 78.6 dBA. Adding simulated background noise raised these levels to at least 85.9 dBA with the highest found to be 106.1 dBA. The mean level has been calculated to be 93.2 dBA. Hence, the lowest measured increase in level was 1.6 dBA and the highest was 26.8 dBA. The mean increase in level has been calculated to be 14.6 dBA, see Fig 5.

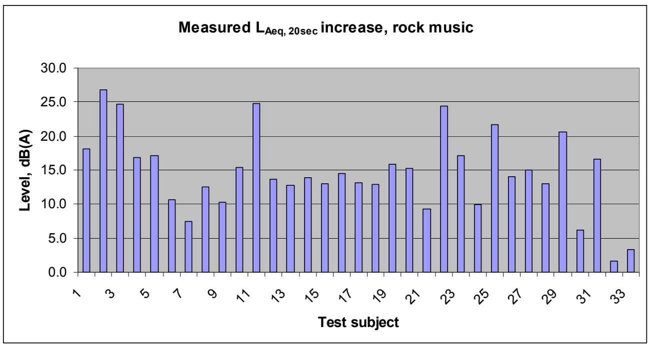


Fig 5. Increase in Rock listening levels for 33 subjects.

For speech, the results show that the lowest measured level was 46.1 dBA and the highest 84.2 dBA. The mean level was calculated to be 66.3 dBA without background noise. When background noise was played the results show that the lowest measured level was 84.6 dBA and the highest 98.3 dBA. The mean level was calculated to be 88 dBA. Hence, the lowest measured increase in level was 11.8 dBA and the highest was 41.6 dBA. The mean increase in level was calculated to be 21.6 dBA, see Fig 6.

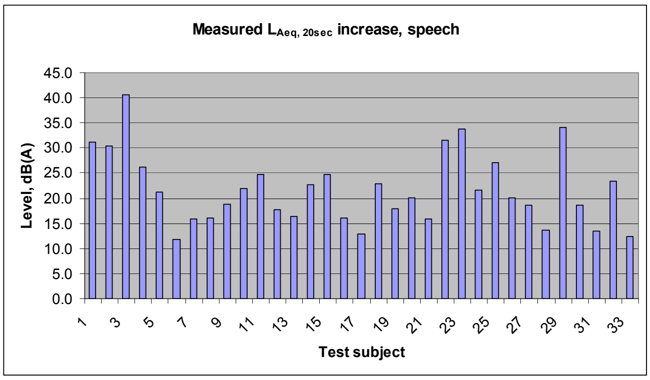


Fig 6. Increase in Speech listening level for 33 subjects.

Output from iPod	Standard deviation		Standard deviation of difference
	Simulated background noise off	Simulated background noise on	
Rock	8.10	4.90	5.84
Speech	8.87	3.41	7.10

Table 1. Calculated standard deviations for the measure noise levels of 33 subjects

The results from the standard deviation calculation, see Table 1, show that the measured data varies more when there was no background noise present, compared to the levels measured when background noise was present. This could suggest that the advent of background noise forces the listener to adjust the volume setting to a level which is above the noise floor but also below the threshold of pain.

Noise Exposure

The Control of Noise at Work Regulations 2005 sets action values for daily noise exposure and peak noise, both with and without hearing protection. The values are given in the units $L_{EP,d}$, which denotes the exposure over a typical working day (8 hours). Specifically, this gives rise to the following:

Lower exposure action values $L_{EP,d}$ is 80 dBA

Upper exposure action values $L_{EP,d}$ is 85 dBA

In summary, an exposure level of 80 dBA $L_{EP,d}$ or over is considered to be detrimental enough to a persons hearing that the Health and Safety Executive recommends hearing protection. The results for each test subject are shown in Table 2. It should be noted that these exposures were calculated for just 1 hour iPod use, as this was found through questionnaires to be typical for 21-30 year olds, 53 minutes for regular iPod users, verifying the Deafness Research UK/BMRB figures [3]. The older the age group, the less the regular users were exposed to their iPod, for instance 33 mins for 31-40 years' olds.

Conclusions

Listening levels using in-ear earphones for 1 hour per day were acceptable when used in a quiet environment; only 2 subjects had dangerous levels of calculated noise exposure, occurring only when listening to rock music, see Fig 7 and 8. Pop music was found to be of limited risk and speech posed no risk from noise exposure. However, when the environment changed to include underground train noise 13 subjects (39%) had dangerous levels of noise exposure when listening to rock music. In additional, there was a considerable increase in the number of subjects with some risk from noise exposure, for Pop music, 23 subjects (70%), and a Speech podcast , 11 (33%).

Further work will include audiometrically testing those subjects with particular high listening levels to determine if it's a personal preference or they have higher levels of hearing loss than the other subjects.

Acknowledgements

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References

[1] P. Wash, Investigation into noise levels produced by personal mp3 players, MSc Thesis, London South Bank University, 2007.

[2] C. Cox, J. Fligor, Output levels of commercially available portable compact disk and the potential risk of hearing , Lippincott Williams and Wilkins, USA

[3] Deafness Research UK/BMRB - Telephone omnibus survey – iPod generation, Beattie Media.

Test subject	$L_{EP,d}$ (dBA) for 1 hour of iPod exposure, simulated background noise off			$L_{EP,d}$ (dBA) for 1 hour of iPod exposure, simulated background noise on		
	Pop	Rock	Speech	Pop	Rock	Speech
1	54	63	47	78	81	78
2	64	58	47	81	85	78
3	51	59	37	80	83	78
4	65	63	51	82	80	78
5	73	67	59	82	84	80
6	74	72	68	83	82	80
7	76	79	67	81	86	83
8	71	68	62	84	81	78
9	66	71	57	76	81	76
10	69	67	60	80	83	82
11	60	54	51	77	79	76
12	57	66	61	80	82	79
13	72	67	61	80	80	77
14	71	64	53	76	78	76
15	68	68	51	79	81	76
16	68	65	61	80	79	77
17	78	71	68	80	84	81
18	69	72	56	75	84	79
19	76	81	71	95	97	89
20	64	72	62	84	87	82
21	72	79	62	81	88	77
22	55	52	44	76	77	76
23	58	71	42	81	88	76
24	67	73	56	81	83	78
25	81	74	57	95	96	84
26	62	65	56	77	79	76
27	74	73	61	83	88	80
28	73	75	67	84	88	81
29	62	61	43	79	81	77
30	78	79	59	81	86	77
31	69	76	75	81	93	89
32	66	85	52	78	86	76
33	79	85	65	81	89	78

Table 2. Noise exposure level calculated based on 1 hour of iPod use and 7 hours of quiet. Grey boxes exceed the Lower Exposure Action Value / Red exceed the Upper Exposure Action Value