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Investigation into MP3 player noise levels when using Noise Cancelling Headphones

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ABSTRACT

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 and researched recently. This study compared listening levels for 20 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 Bose noise cancelling headphones. The noise levels were measured using a Binaural Head and Torso. The participants had time to adjust the volume to a comfortable setting on each occasion. Results showed that the listening levels were significantly lower using the Bose headphones than with the supplied in-ear earphones. Only 10% of subjects listening to the rock music at levels above the upper exposure limit based on 1 hour of listening.

1. INTRODUCTION

Personal stereos were commercially released during the late 1970's; ever since the release they have continued to be a popular product for consumers. There has been a rapid increase in the number of MP3 player sales since they're release and with rapid technology development they are continuing to be a success among today's consumers. Ever since the release of personal stereo's there has been concern regarding noise levels emitted via the headphones in relation to hearing and its effects. It has been stated that a high percentage of consumer's who use portable music devices are unaware of the dangers of listening to audio at high levels whilst using headphones.

This paper looks at the effects personal stereos has on human hearing whilst wearing noise canceling headphones and as compared to a previous study which used the iPod earphones [1]. A number of subjects were tested in terms of the volume they listened to various types of music. Each subject listened to a portion of each track under different circumstances. The circumstances included listening to the tracks in the presence of no background noise and finally in the presence of London Underground train noise.

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The research was driven by the (2005) UK Noise at Work Regulations which set a maximum exposure limit of 87 dB(A) averaged over an 8 hour working day. The papers attempts to establish if a good set of headphones can significantly reduce the noise exposure of a typical London commuter. For more information please read [2]

2. MP3 NOISE LEVELS AND THE ENVIRONMENT

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 typical commute. Noise levels were measured to be 84 dBLAeq,2min, with the highest single event of 96 dBLAFmax. The wave file of the underground train journey was used as the background noise in the following experiment. For more information see [1]. These noise levels were in agreement with those measured by the UK Noise Association [3]. In February 2009, London Underground reduced the service on the Central Line due to noise.

Brian Fligor, an audiologist, tested 100 subjects by measuring how loudly they listened to their MP3 players in different background noise environments. He found that no matter what type of headphones used 6% of subjects listened to music at loud levels when the background noise was quiet. However 80% of participants listened to music at loud levels when the environmental background noise was loud [4].

3. MEASURMENT OF MUSIC AND SPEECH SIGNALS

Three 'tracks' were chosen for the experiment, Madonna-'Get into the Groove', Skidrow- 'You've gone wild' and a 'news podcast' that included only speech. The genres of music chosen were 'Rock' and 'Pop' as these are considered to have varying spectral content, as used in [1].

The measurement procedure for the 20 randomly selected subjects was as follows:

1. The user was seated in a chair next to a binaural head in an anechoic chamber.
2. headphones were adjusted for comfort
3. a track was played through the headphones whilst the user adjusted the volume
4. the headphones were placed on the binaural head and a 15 second sample measured
5. repeat for the 2 further tracks
6. repeat with underground train noise played from laptop using Adobe Audition
7. fill out a questionnaire

The measurement apparatus can be seen in Figures 1 – 4.

Figure 1 – Bose headphones and Ipod

Figure 2 – Nor 121 and Laptop Audition setup

Figure 3 shows the headphones fitted over the binaural head. A Norsonic 121 analyzer was used to measure the listening levels from the binaural head- calibrated using a CEL 282. Figure 4 shows an overview of the experiment.

Figure 3– Binaural head with Bose headphones in place

Figure 4 – Equipment set-up

Each participant completed a questionnaire regarding their individual hearing, use of MP3 players, if any, medical issues and information regarding they're noise exposure both in the past and currently. The questionnaire has been designed to give information regarding the subject's current state of hearing; this will allow comparisons to be made with the answers given and their actual recorded volume levels.

4. QUESTIONNAIRE RESULTS

A. Hearing

The majority of subjects were 21-30 years old, 55%. The 31-40 were 15%, as were the 51-60 group. The smallest group was the 61 and over with 5%. Finally the remaining 10% were formed from the 41-50 year olds.

The subjects' subjective opinion of their own hearing found that 70% of subjects regarded their current state of hearing as 'good'; with the remaining 30% stating they have 'little trouble'. Objectively, 65% of the subjects have had their hearing tested. Of the subjects tested 38% had their hearing tested within the last year. Another 38% had theirs tested in the last 1-4 years and the remaining percentage had their hearing tested more than fours years ago. It was also found that none of the tested had had to wear a hearing aid.

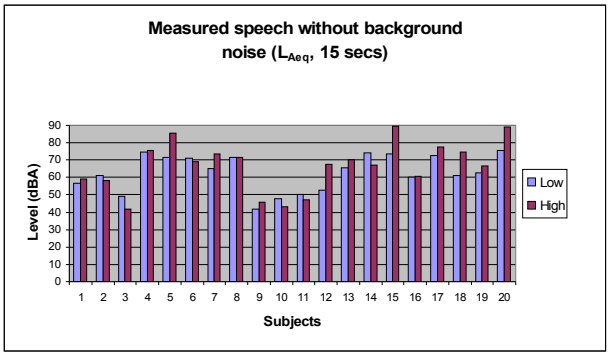
B. MP3 Listening Habits

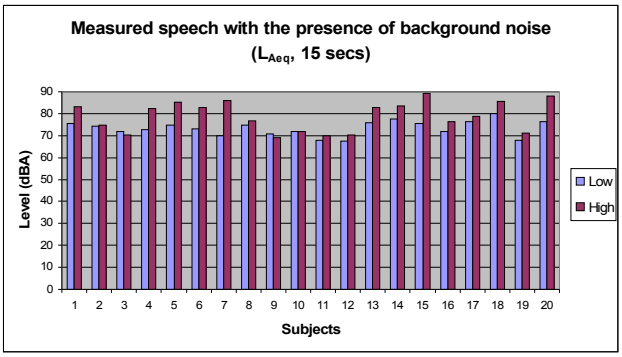
In terms of listening habits 20% of participants stated that they don't use MP3 players, whilst results show the usage for the remaining subjects range from everyday to once a month. For the youngest group 45% used a player every work day, 36% at least once a week, the remainder every month. For the 31-40 year olds, it was an even split between daily, weekly and monthly. For the 41-50 group 75% use an MP3 player every week, 25% not at all. For the over 60's there was no regular MP3 use recorded.

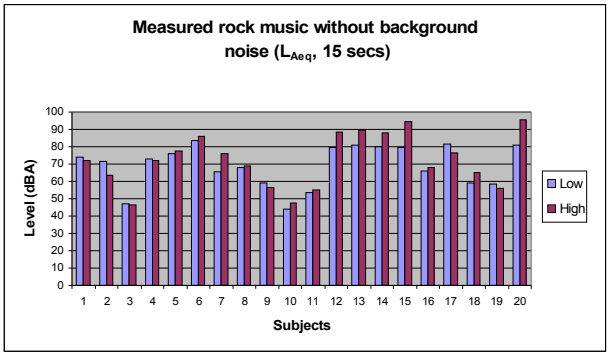
5. LISTENING MEASUREMENT RESULTS

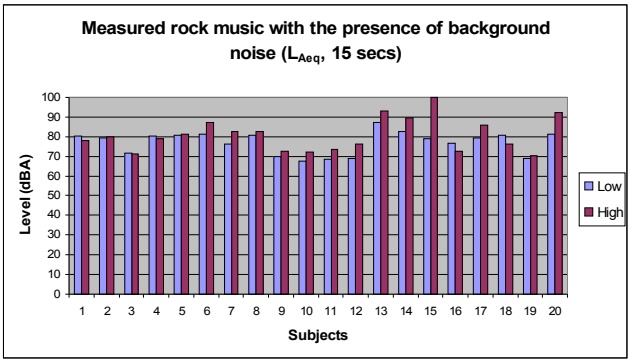
The headphones have two settings, 'low' and high'. The subjects set volume levels accordingly using both the settings. It was found that when using the 'high' setting the noise was being amplified, where as on the 'low' setting the noise cancellation would become active. Allanalysis is based on the high setting results.

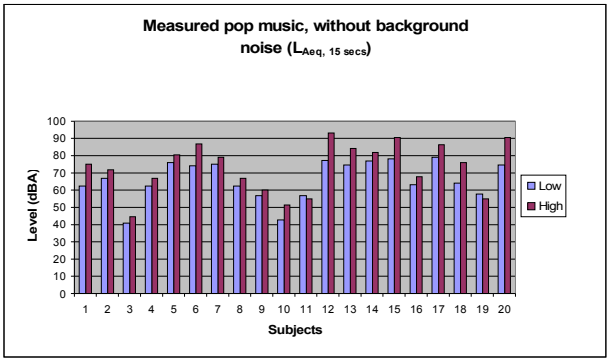
It was initially found that the iPod had been fitted with a volume limiter which was affecting the results and was also found to be unsuitable when listening to the tracks whilst the train noise was present. This problem was soon rectified by adjusting the settings and removing the limiter.











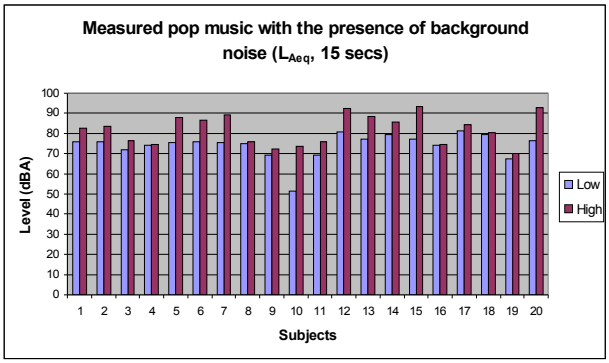


Figure 5: Listening Levels with noise (Hi/Low Setting) **Figure 6**: Listening with background noise

It can be seen from figure 5 that without background noise the listening levels were similar for the three tracks, a lowest level of approximately 45 dBA and a maximum of 90-95 dBA. However, when train noise was introduced, figure 6, the 50 dB differential was reduced to 12 dBA, the maximum level increasing only 1-4 dBA above the no noise measured listening level.

Table 1: *Average Listening Levels for the 3 tracks using Bose Headphones (dBA)*

	Speech	Pop	Rock
No Noise	66.7	73.1	72.2
Train Noise	78.9	82.0	80.9

After averaging the 20 subjects' listening levels, the noise exposure levels were found to be safe even when the train noise was introduced, see Table 1. The differential between no noise and train noise was found to be significantly greater for speech, 12 dBA, than for music 9 dBA.

Table 2 : *Exposure levels without **and with train noise** for 3 tracks*

Subject	Speech $L_{EP,d}$	Pop $L_{EP,d}$	Rock $L_{EP,d}$	**Speech $L_{EP,d}$**	**Pop $L_{EP,d}$**	**Rock $L_{EP,d}$**
1	49	65	62	73	73	68
2	48	62	53	65	73	70
3	32	34	37	60	66	61
4	65	57	62	72	64	69
5	75	70	67	75	78	71
6	59	76	76	73	76	77
7	63	69	66	76	79	73
8	61	57	59	67	66	73
9	36	50	46	59	62	62
10	33	41	37	62	64	62
11	37	45	45	60	66	64
12	57	83	78	60	82	66
13	60	74	80	72	78	83
14	57	72	78	74	76	79
15	79	80	85	79	83	90
16	51	58	58	66	64	62
17	67	76	66	69	74	76
18	64	66	55	75	70	66
19	56	45	46	61	60	60
20	79	80	85	78	83	82

From Table 2 it can be seen that the Bose headphones could provide a comfortable personal environment even when 82 dBA train noise was played. Only 1 subject was exposed to dangerously high music levels, for the Rock track. No one was exposed to speech listening levels above the lower exposure limit value, 80 dBA with or without train noise.

Comparing the results with the previous study, which used Apple earphones [1], the percentage of subjects listening at levels above the lower exposure limit value were identified, see Table 3.

Table 3: *Percentage of subjects listening to the tracks at levels above the lower exposure limit value*

	No Noise			Train Noise		
	Speech	Pop	Rock	Speech	Pop	Rock
Apple Earphones	0	3	9	33	70	85
Bose Headphones	0	15	15	0	15	15

From Table 3 it can seen that when no noise the use of the Apple and Bose listening devices give very similar results, a small percentage of people listen above 80 dBA. However, when train noise is introduced a significant proportion of Apple Earphone users listen at noise levels above 80 dBA. This compares to only a small percentage of people listening at these levels using the Bose Headphones.

6. CONCLUSIONS

A follow up study concerning listening levels of subjects under conditions similar to those on London Underground was undertaken. This study used Bose noise canceling headphones rather than the standard Apple earphones. It was found that under quiet conditions there was limited difference between the earphones and headphone. However, when train noise was introduced there was no similar increase in noise exposure when the users were using the Bose headphones, as was previously found when using the standard earphones.

ACKNOWLEDGMENTS

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