EFFECT OF HEADPHONE TYPE ON LISTENING LEVELS AND LOCALIZATION ABILITIES OF PORTABLE AUDIO DEVICE USERS IN QUIET AND TRAFFIC NOISE

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1. INTRODUCTION

The sales of different portable audio devices (PAD; such as MP3 players) have witnessed a boom during the last decade (Hodgetts, Rieger, & Szarko, 2007). Their popularity is particularly increasing among young adults. The output of these devices can be high enough to pose a risk of hearing impairment (Fligor & Ives, 2006), depending on several factors, such as the volume setting, listening duration, and music type.

Many PAD owners wear their devices in noisy situations such as in cafeterias, on the street, or while commuting by bus, streetcar, or subway. When worn in noise, wearers typically increase the volume setting to maintain an adequate music-to-noise ratio. Noise-reduction headphones can help reduce the risk of hearing impairment associated with the use of PAD in noisy background by blocking some noise, hence decreasing the need for increased volume levels. However, these headphones may affect the wearer's ability to spatially locate important environmental sounds such as approaching cars. The present two studies examine the effects of headphone type and background noise on sound localization abilities and PAD output levels.

2. GENERAL METHODS

Participants were normal hearing adults, aged 21 to 30, who owned and used PADs for the purpose of listening to music. All completed a hearing history survey and participated in two stages of data collection: real-ear measurements of their preferred listening levels (PLLs) and a sound localization task. All tasks and measurements were conducted in a hemi-anechoic chamber. Participants were seated in the centre of a multi-speaker array at a 1.5 meter distance from all speakers. Stimuli and noises were presented via a 360° subset of 8 speakers (separated by 45°) at the height of the listener's ear.

2.1 Real-Ear Measurements

A probe-tube was inserted in left ear canal of each participant, medial to the output of the headphone and within 5 mm of tympanic membrane (Audioscan, 2007). Measures of room noise in the ear canal and PLLs in the ear canal (headphones, with music playing, adjusted by user to PLL) were conducted both in quiet and with a background of recorded stereo traffic noise.

2.2 Sound Localization Task

Participants were seated facing forward (0° azimuth) in the centre of the speaker array. Upon hearing a target stimulus, they turned and used an electromagnetic pointing device to indicate which speaker was the source of the target stimulus. Participants returned to the 0° position and the next stimulus was presented.

3. STUDY 1

Four listening conditions were tested: an open ear condition and three lower-priced over-the-counter transducers: an ear bud (Samsung EP370), over-the-ear headphones (Sony - MDR 210-LP), and noise-reduction insert earphones (Skullcandy Smokin' Buds SCBUDP). Twenty participants were tested in quiet (ambient noise < 30 dBA) and in 83 dBA traffic noise.

As expected the participants' PLLs increased when listening to music in the background of traffic noise, as shown in Table 1.

Table 1. Real ear measures of noise (Open ear) and noise combined with MP3 music set to PLL (Music)

	Open ear		Music					
			Ear bud		Over-the-ear		Noise reduction	
	M	SD	M	SD	M	SD	M	SD
Quiet	53.4	0.7	65.3	8.8	66.3	9.6	61	9.1
Traffic noise	83.9	2.3	85.1	5.6	89.5	4.1	77.7	6.9

Localization performance decreased when the participants were listening to music through the MP3 player (Table 2). In particular, there was an increase in the back-front errors (stimuli at the back were perceived to be in front) when over-the-ear phones were worn.

Table 2. Localization errors by headphone type in Quiet and Traffic noise conditions

Headphone type	Quiet			Traffic			Increase
	M	SD	%	M	SD	%	M%
Open Ear (no music)	6.4	3.2	26.7	8.9	3.8	37.1	2.5 (10.4%)
Ear bud	8.5	3.3	35.4	10.4	2.8	43.3	1.9 (7.9%)
Over-the-ear	8.1	2.5	33.8	11.3	2.4	47.1	3.2 (13.3%)
Noise reduction inserts	10.3	2.2	42.9	11.2	2.2	46.7	0.9 (3.8%)

4. STUDY 2

Four listening conditions were used that included an open ear condition and three transducers designed to reduce background noise: ER6i insert phones, Sony MDR-NC6 Noise Cancelling headphones, and Bose QuietComfort 2 Acoustic Noise Cancelling headphones. Participants were tested in quiet (ambient noise < 30 dBA) and in 70 dBA traffic noise.

The PLLs of 19 participants increased in background noise conditions (Table 3). The number of localization errors increased when listening to music through the noise-cancelling headphones (Table 4), and are higher than observed in study 1 in spite of the lower traffic noise levels, suggesting that the noise-reduction headphones degrade localization abilities. Error analyses indicated that back-front errors were the most common error type followed by front-back and lateralization errors.

Table 3. Real ear measures of noise (Open ear) and noise combined with MP3 music set to PLL (Music conditions)

	Open ear		Music					
			Bose		ER6I		Sony	
	M	SD	M	SD	M	SD	M	SD
Quiet	52.5	0.9	63.4	8.7	71.8	11.6	67.9	10.8
Traffic noise	70.1	5	66.9	7.3	75.2	9.5	76.2	7.3

Table 4. Localization errors by headphone type in Quiet and Traffic noise conditions

Headphone type	Quiet			Traffic			Increase
	M	SD	%	M	SD	%	M%
Open ear	7.4	3.2	30.7	9.1	3.6	37.9	1.7 (7.2%)
Bose noise cancelling	12.1	3.9	50.2	14.3	3.8	59.4	2.2 (9.2%)
ER6i inserts	13.9	4.5	58.1	12.5	4.8	52	-1.4 (6.1%)
Sony noise cancelling	13.7	4.4	58.1	14.1	2.8	58.8	0.4 (0.7%)

5. DISCUSSION

The amount of and type noise reduction provided by the earphones varied considerably among the different types as did the wearer's PLL in a background traffic noise. Some of the earphones provided some sound attenuation by occluding the ear canal (ER6i) while others provided active noise cancellation. Shah et al. (2009) reported that 85% of PAD users are concerned about hearing loss, and willing to protect their hearing. The use of noise reduction headphones may reduce a listener's PLL in noisy environments and thereby reduce the risk of noise-induced hearing loss.

Localization errors were more common when listeners were wearing PADs and slightly higher, on average, when they were wearing them in a background of noise. The type of headphone worn influenced the number of localization errors, with the greatest localization problems occurring while the noise reduction devices were being worn regardless of the background noise condition.

News reports of pedestrians and bicyclists being hit by cars while wearing PADs are not uncommon, nor are they surprising given these results. Wearers should be made aware of the difficulties in identifying the source of warning signals when in an environment posing a physical safety hazard (e.g. walking in traffic).

REFERENCES

Audioscan (2007). *Verifit Hearing Instrument Fitting Guide (Version 3.0)*. Dorchester, Ontario. [Available: http://www.audioscan.com/resources/usersguides/Currentverifitguide.pdf]

Hodgetts, W.E., Rieger., J.M., Szarko, R.A. (2007). The effects of listening environment and earphone style on preferred listening levels of normal hearing adults using an MP3 player. *Ear & Hearing, 28*, 290-297.

Fligor, B. J., & Ives, T. E. (2006). *Does earphone type affect risk for recreational noise-induced hearing loss?* The NHCA Conference on Noise-Induced Hearing Loss in Children at Work and Play.

Shah, S., Gopal, B., Reis, J., Novak, M. (2009). Hear Today, Gone tomorrow: an assessment of portable entertainment player use and hearing acuity in a community sample. *Journal of the American Board of Family Medicine,* 22, 17-23.

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The work described in study 1 was conducted while R. Malcolmson was a student at the University of Western Ontario. Her current address is Central Speech and Hearing Clinic, Winnipeg, MB R3T 4J6.