

Audiology and music. Two things that go together pretty well. This past summer, as I was reading about the AAA preparing to celebrate its 20th anniversary, I was reminded that it was the 40th anniversary of the “Summer of Love.” In addition to Jerry Garcia and the 75,000 hippies in San Francisco, a lot was happening in 1967. Jerger and Jerger were showing us how to differentiate cochlear from nVIII lesions; Sgt. Pepper was showing us a new era in popular music.

While Sam Lybarger was writing about earmold acoustics, a fellow named Bob Dylan was in seclusion not too far up the road in a place called Woodstock, doing some acoustics of his own. The hippies had LSD, we got high on the SISI and ABLB!

It was also around this time that many of us decided it was good to listen to music loud. Loud music became portable 12 years later when the Sony Walkman was introduced. And so here we are again, audiology and music; sometimes loud music, sometimes portable music, and sometimes a resulting noise-induced hearing loss.

When you’ve been spoofed on the David Letterman show, you know that you either are a politician, on your way to rehab, or an audiologist whose name has been splashed around in the lay press. The latter was the case for our Page Ten author, as last year his name showed up in several newspaper articles related to hearing loss and portable loud music. **Brian Fligor**, ScD, is the director of diagnostic audiology at Children’s Hospital in Boston and holds a faculty appointment as an instructor in the Department of Otology and Laryngology at Harvard Medical School.

His primary research interests are investigating causes of acquired hearing loss, particularly in the pediatric population. Much of his work is summarized in a book chapter coming out soon in the new edition of *Musicians and Hearing Loss*. It probably doesn’t surprise you that Dr. Fligor is a musician himself; you can read all about his music ventures and his hit song *Psychotic Polka* at earTunes.com.

Many of you readers are too young to remember the summer of 1967, but you can have your own love fest today! Drop a couple ABLBs at work, then go home and sit down with Brian’s excellent article, accompanied with some good Grateful Dead music. If you can read fast, it’s probably even okay to listen to it loud (but not too loud)!

GUS MUELLER
Page Ten Editor

Hearing loss and iPods: What happens when you turn them to 11?

By *Brian Fligor*



Fligor

1 I know you told me I have 20 questions, but let’s just cut right to the chase: Do iPods cause hearing loss?

You just can’t wait, huh? As we all know, lots of things cause hearing loss. In most older men with hearing loss, we know that their hearing loss was most often caused by a combination of the aging process and the accumulation of a lifetime of damage from noise. How much is from aging and how much from noise (or ototoxic medications, etc.) depends on the individual. So, do iPods, and any other types of portable music players, which I’ll call PMPs for short, cause hearing loss? Yes, they can contribute.

2 How do you know that PMPs contribute to a person’s hearing loss?

I said they “*can* contribute,” with emphasis on *can*. Much of our understanding of how much noise exposure is required to cause noise-induced hearing loss (NIHL) comes from large studies of noise exposure and the prevalence and degree of hearing loss in factories in the 1970s.

You probably recall hearing about the Occupational Noise and Hearing Survey (ONHS), which was conducted by the National Institute for Occupational Safety and Health (NIOSH) from 1968 to 1972 and included nearly 1200 predominantly white males from a cross section of industries within the United States. We don’t have that kind of large population data for music exposures. The few studies that have measured or estimated noise exposure and compared it with observed hearing loss have used sample sizes of a few dozen, not a few thousand.

What we do know is that music does affect hearing in a time- and level-dependent manner, and we know that the output levels delivered by headphones are sufficient to result in an over-exposure if used for a sufficient duration.

3 So, if headphones can play music at such high levels, why don’t manufacturers, or the government, limit the max level to one that’s safe?

What level would that be? You might suggest a time-weighted average (TWA) of 90 dBA, but 8 hours of exposure to 90 dBA isn’t exactly “safe” (a fair percentage of people develop quite a hearing loss from continued 8-hour time-weighted average exposure to 90 dBA). France limits PMP headphone output to 100 dBA. Is that safe? By some standards, a person shouldn’t listen for more than 15 minutes at that level.

If we limit the max level to 80 or 85 dBA, the headphones would be unusable in many situations, such as flying on an airplane, riding a subway, or walking down the street in downtown Boston or New York. This “level worship” oversimplifies the problem and the solution.

Additionally, it isn’t the capacity of the headphone, but how people use it, that determines risk for NIHL. It is perfectly appropriate for a person to crank up the volume for his favorite song, as long as it’s only for one song or not for long durations every day. No mass-market headphone that I’ve encountered can cause an acoustic trauma (immedi-

ate loss of hearing after a single exposure), so there is no concern for immediate hearing loss. My personal opinion is that it's the duration of listening that is more problematic than the level a person chooses to listen at for any given time.

4 Okay, so if it isn't as simple as limiting the output level, what is the solution?

As you might guess from my last answer, I'm strongly "pro choice" when it comes to level limiting. I believe in allowing the informed consumer to make his or her own decisions about the amount of headphone use.

Informed consumers would have both access to NIHL education (something sorely lacking in our public school health and science curricula) and meaningful real-time information about their headphone use and how their behavior may be affecting their hearing. The Congressional Hearing Health Caucus has requested that the Centers for Disease Control and Prevention (CDC) add hearing health to the list of important health topics to be taught in the public school system. This effort would go a long way toward helping improve the understanding of the risks of NIHL.

5 By "meaningful real-time information" do you mean a decibel level readout for the PMP volume control?

Possibly, but again, looking at only the decibel level is short-sighted. It would be more useful to the consumer to be provided with an accurate record of his or her cumulative exposure. While the actual level in the ear would be helpful, the cumulative level over time (and an explanation of what that means to hearing loss risk) would be even more useful.

6 That sounds complicated. Why can't I just hold a sound level meter up to a headphone and measure the level?

Would you do that to check the MPO of a hearing aid? No! Headphones, like hearing aids, are meant to be used in a coupler (the ear), and so must be measured in a coupler.

7 Didn't the American Speech-Language-Hearing Association do sound level measures of iPods as part of some public awareness campaign?

Yes, ASHA put a lot of effort into that

campaign, which was called "Listen to Your Buds." Readers should check out www.lis-tentoyourbuds.org. I was pleased to help with a little of that campaign, participating in press releases and press conferences. That said, I did not help with the sound level measures. ASHA reported that PMP headphones produced 110 to 125 dBA (the iPod max was 120 to 125 dBA).

My understanding is that dBA was measured in a 2-cc coupler, and I don't doubt it is an accurate report of the levels in that coupler. Unfortunately, to make any decisions about the risk posed by listening with the volume control of the PMP turned way up (by comparing measured sound levels to damage-risk criteria based on those huge factory-noise studies by NIOSH from 1968-1972) you *must* figure out (and report) the free-field equivalent of the level measured in the 2-cc coupler.

8 Free-field equivalent?

Yes, it's an "apples to apples" thing. Think about this. Take a broadband noise and play it through a loudspeaker in a room and measure the sound level at someone's shoulder. Now, measure that same noise with a probe microphone placed down the ear canal near the eardrum. The probe-mic level will be on the order of 10 to 15 dB higher than the shoulder (free-field) level because of the resonance in the coupler (the ear).

The difference between eardrum and shoulder would be the "coupler to free-field" transfer function (a transfer function because it is frequency dependent). Our guidelines and regulations (based on damage-risk criteria derived from factory noise studies [the ONHS work]) were all based on free-field sound level measures, not probe-mic ear canal measures. So, you can't compare the "apples" of 2-cc coupler measures to the "oranges" of free-field damage-risk criteria.

Moreover, we also know that the output in a 2-cc coupler may be quite different from what is in the average ear canal, depending on what type of headphone the person is using.

9 I was going to ask about that. Let's talk about the type of headphones people use. Does it matter?

The popular media would have us think

that in-ear or earbud type headphones are more dangerous than headphones that sit on top of the ear or surround the ear. But again, this issue is along the lines of “level worship.” Just because a sports car can go 40 mph faster than a sedan at top speed doesn’t mean you drive it 40 mph faster.

My colleague Terri Ives and I have a manuscript in preparation that reports results demonstrating that when you control for background noise and earphone isolation, the type of headphone has essentially no bearing whatsoever on a PMP user’s chosen listening level. Specifically, our study took 100 subjects and had them listen to an MP3 player and set the level of the music to where they liked it. We varied the background noise in the listening environment while we measured sound levels in the ear via probe microphone (we corrected for free-field equivalent offline).

Additionally, we measured the amount of ambient sound isolation provided by each of the four different earphones for each of the 100 subjects. We chose these four different earphones because they were over-the-ear and earbud styles, and two of them were engineered to provide some level of sound isolation while the other two did not.

The earphones that were *not* engineered to provide sound isolation were an over-the-ear earphone made by Koss and an iPod earbud. Both provided (on average) 1 dB of sound isolation (very little). Impressively, people chose almost the exact same level with the Koss over-the-ear and the iPod earbud in all background noise conditions, even though one was over-the-ear and one was an earbud. There was a big difference, though, in the chosen listening level in higher levels of background noise when subjects were using sound-isolating earphones.

10 I'd like to hear more about the sound-isolating earphones, but first I have to ask, don't the earbud style headphones go louder than over-the-ear?

It’s true that, generally speaking, headphones that are situated over the ear canal entrance or are placed in the ear canal produce higher sound levels at the same volume control setting than those that sit on top of the ear or surround the ear. This is in part because the in-ear or earbud ear-

phones act on a smaller volume of air. It takes less energy to create higher sound levels in a smaller space.

This was described in detail in a paper by Susan Voss and colleagues in *JASA*¹ and also in a paper I published a few years ago with Clarke Cox about CD player output.² Our paper was an effort to provide a reasonable “speed limit” for using headphones. We observed that the in-ear and earbud-style earphones produced 7 to 9 dB higher output than the over-the-ear earphones at the same volume control setting. Unfortunately, the popular media over-interpreted this observation and earbud-style headphones got a bad rap!

11 So, what was the “speed limit?”

Based on the measured free-field equivalent sound levels from CD player headphones and a conservative estimate of damage risk for different listening durations, a CD player user could listen at 60% of the maximum volume for 60 minutes or less using the included over-the-ear headphones without substantially increasing risk of NIHL.

12 I've heard of some “60/60” rule for headphone use. Is this where that came from?

Yes. You can thank our Canadian friend Marshall Chasin, who coined that term to refer to this guideline. I personally wouldn’t go so far as to call it a “rule” since it is much too easily violated. For instance, swapping out headphones from the stock earphone throws off the numbers. When I say “stock” I mean the over-the-ear earphones that came with most of the CD players we evaluated in our 2004 study.

The “60/60” rule generally applied to CD players using these stock earphones, but change to a different earphone (like an earbud earphone) and the 60% for 60 minutes or less wasn’t appropriate anymore. Using a more subtle analogy, if you put tires on your car that were a different size than they are supposed to be, your speedometer will be off by a few miles per hour. How far off depends on how much bigger or smaller the tires are than the original factory tires.

13 Not many people carry a CD player around with them anymore. Does the 60/60

rule also apply to iPods?

No, it doesn’t. Cory Portnuff, an audiology student at the University of Colorado, and I have just completed our work on output levels of MP3 players to update the “speed limit” guideline. Using the stock earbud with an iPod (or any of the other MP3 players we examined), a person could listen at 80% of the maximum volume for about 90 minutes or less without substantially increasing risk for NIHL.

14 So are you saying that MP3 player output levels are lower than CD players?

Yes. Remember though, lower maximum level does not make headphones safe, just as higher max level does not necessarily make them unsafe.

15 So why all the media hysteria over iPods? What makes them riskier to use than the systems we were using in the past?

Good question, and that’s an important point: They may *not* be riskier.

Abusing headphones has always posed some level of risk to hearing. The attention given to iPods comes in part from the extraordinary popularity of the device (over 100 million sold since 2001).

There is also the probability that people use MP3 players for longer periods of time than they used CD or tape players. As part of ASHA’s public awareness campaign, Zogby conducted a poll that asked people about the length of time they used MP3 players. Of the adults who reported using MP3 players, 43% said they used headphones 1 to 4 hours a day and 9% said they used them more than 4 hours a day. The capacity to listen for longer durations may indeed reflect the potential for increased risk. So, the media hype may not be entirely unfounded.

We should also consider, though, that the media has a product to sell and controversy makes it easier to sell! So, it’s in their interest to oversell the perceived risk from the most current “king of the hill” with PMP technology.

16 So, we've made our way back to my first question: Is there any risk of suffering NIHL from listening to music on iPod headphones?

Yes, there is. The sum of the literature suggests that between 5% and 15% of headphone users listen at high enough levels and for long enough durations to put themselves at risk. Data from the study Terri Ives and I conducted, which I mentioned earlier, showed that the risk is highly situational. That is, NIHL risk depends on the user's listening environment.

Now, if we consider the conservative estimate of 5% at risk, and consider that only 10% of these people will listen for enough months and years for NIHL to develop, that's only 0.5% of headphone users. That is a small percentage, but in absolute numbers, consider that 0.5% of 100 million iPods sold is 500,000!

17 You mentioned background noise and earphone isolation earlier. How do they relate to how people set their volume?

I'm glad we got back to this, as this is an important point. In our study, we found that the level of background noise had a direct effect on a user's chosen listening level. For instance, in a quiet sound booth (background noise level is low, about 28 dBA) about 6% of headphone users chose

levels above 85 dBA. (We might consider 85 dBA as a cutoff for "riskier listening behavior.")

When background noise was raised to 80 dBA of airplane cabin noise (as though subjects were listening to their headphones while flying on an airplane), 80% chose levels above 85 dBA. This was seen irrespective of whether they used an earbud or an over-the-ear earphone, as long as the earphone provided no sound isolation.

However, when subjects listened in that airplane noise condition using the ER6i (Etymotic Research, Inc.), an earphone with sound isolation, only 20% listened above 85 dBA. This earphone provided an average of 25 dB of sound isolation according to our measures for each of our 100 subjects.

18 So, blocking out the background noise really does help reduce the risk for NIHL, right?

Yes, using a sound-isolating earphone will generally cause a person to moderate their listening levels. This assumes that it isn't necessary for the person to be able to hear in their surroundings (that is, it's not nec-

essary for safety or communication reasons to be able to hear well).

Consider it a matter of signal-to-noise ratio. If background noise is masking the sound you want to hear (like music), you'll turn up that signal. In a noisy background (for example, on a plane), people will typically turn up the music so they can hear it over the noise. For those people who would usually choose a moderate level in quiet, but turn it up in high background noise, using sound-isolating earphones has a direct impact on listening behavior.

19 This is all good information, and I'm thinking about how I will use it. What should I be telling my patients, or the parents of my patients?

You should tell them that it's possible to abuse headphones. The best way to avoid that is by limiting both listening level and listening duration. Using a sound-isolating earphone will immediately induce most people to listen at moderate levels in background noise.

As for the "speed limit," the exact level depends on the headphone and PMP. A reasonable rule-of-thumb for people who use the standard PMP and headphone is to listen at 60% for 60 minutes (or less) for a CD player and 80% for 90 minutes (or less) for an MP3 player during any 24-hour period. But above all, let parents know that because they are concerned about this problem, their children are less likely to experience hearing loss! Recommend that parents practice safe listening practices (moderate their own listening levels, use earplugs when engaging in noisy activities) and their children will model that behavior. And, of course, get their hearing tested regularly.

20 But what if I want to turn it up to 11?!

Well, Nigel (you know, Nigel Tufnel from Spinal Tap!), I told you, I'm "pro-choice!" Turn it up to 11 if you want. Just be aware of how long you can listen to it without putting your ears at risk.

REFERENCES

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