

Q&A: Researcher explores how musicians, teachers can prevent noise-induced hearing loss

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Kris Chesky was well into his career as a musician-researcher working on music-related injuries when an audiologist colleague suggested he try

out a set of custom-made musician earplugs. The audiologist fitted the earplugs by making silicone molds of his ear canals. When the earplugs arrived, he was surprised by how they felt when he played trumpet.

"I brought them to a gig. I couldn't even get through one song with them in my ears. They just hurt," says Chesky, who is Bloomberg Distinguished Professor for Performing Arts Health at Johns Hopkins. "When I began to play, the position of my jaw was different than it was when I had the molds made. My ear canal had changed shape. The plugs did not really fit into my ears. They did not work for the very use case for which they are intended."

Despite working with the audiologist to achieve a better fit, Chesky started to wonder how other musicians were experiencing these musician-specific earplugs—which are marketed by their manufacturers as a way to prevent noise-induced hearing loss among musicians of all ages. In the years since he put those plugs in his ears, Chesky has become a leader in researching how well earplugs protect the hearing of their users. His results have called into question manufacturer's claims about the efficacy of their products.

In September, 3M, a major manufacturer of hearing protection for American service members, announced it had reached a landmark \$6 billion agreement to compensate service members suffering from hearing loss after using their popular Combat Arms earplugs. The 3M product was marketed as effective, but did not prevent hearing loss.

"This is a huge story and it shares a lot of parallels with the musician earplug industry," says Chesky. "When I heard about it, I was just floored."

We sat down with Chesky, who was recently appointed as a BDP in the Peabody Conservatory and the School of Medicine, to learn more about

the musician-specific earplug industry, and what might be done to improve how musicians and their teachers prevent noise-induced hearing loss.

What hearing-related health risks do musicians face when they practice or perform?

Musical activities—practicing, playing or listening—generate [sound energy](#) sufficient to influence human hearing health.

The prevalence rates for music-induced hearing disorders are rising due to increased [mobile phone use](#), ear buds, and 24/7 access to as much music you could possibly listen. The American Academy of Pediatricians recently reported that [12.5% of children are at risk of hearing loss](#) and has released a report and recommendations on how to reduce dangerous exposure.

Additionally, the World Health Organization is estimating that more than 1 billion young people right now are at risk for these kinds of problems. The WHO recently pushed out a recommendation for [national standards](#) to ensure that there are limits at festivals and concerts. Those limits would be managed by an audio engineer with speakers and a sound system in place.

There is a whole area of concern where we generate sound levels in our scholastic and professional music ensembles. In schools, ensemble-based learning activities, including courses that students take to learn how to be musicians, are, by and large, not amplified. There's no audio engineer involved. Through my research, I have found that the sound levels generated during these ensembles is driven primarily by the behavior of the musicians who are under the direction of a teacher.

How has the music industry responded to the challenge of preventing student and professional musicians from being exposed to dangerous sound levels?,

Sometimes, musicians and educators find that the musical activity is generating sound levels that are unreasonably high. The main way the industry has tried to prevent hearing loss is through the use of earplugs. A musician might take out a set of these earplugs and attempt to protect themselves.

So-called "musician earplugs" have been marketed to musicians and music programs around the world for over 30 years. There are basically two types.

The first is an earplug that requires an audiologist or a trained technician to make a silicone mold of a musician's ear canals, which functions as the basis for producing a custom fitted earpiece. The piece would have a hole drilled out in the middle, which is intended is to mimic the resonance of the human ear canal. The idea here is to reduce the sound energy levels equally across frequencies in order to maintain the normal timbre or quality of the sound. On the outside of the plug hole there is a place to snap in a filter. Three filter strengths are available. These cost about \$200.

The other type is a patented product that is directly marketed to school music programs. Prices range from \$10 to \$20. These earplugs use a three-flange system, so the part that goes into your ear looks like a Christmas tree. They are not fitted by a professional.

In the marketing of these products, you often see the terms "flat attenuation," "flat response," or "flat frequency response." The claims manufacturers make is that these earplugs will allow a musician to hear the sounds normally and naturally without distortion of the frequency

spectrum. Claims state that these earplugs reduce the amount of sound energy equally across frequencies.

Another fact of note is that a relatively small number of manufacturers are behind most musician-specific earplugs. It seems to be a monopoly due to the trademarks and patents involved. Those manufacturers have been very aggressive in marketing their products to students at every level of experience.

You are a musician yourself. Can you describe the experience of playing music while wearing earplugs?

Wearing earplugs while playing a musical instrument can create many challenges. In an ensemble, feedback is essential. When a musician plays in a group, they are adjusting based on what they are hearing. If I'm playing in an ensemble and I'm sitting next to other people, I can't hear them normally if I wear earplugs. That makes it hard to balance my tone and my dynamic contrast. This can affect the quality of the music I am producing for an audience. I also experience discomfort, feelings of pressure from the earplug, and difficulty perceiving the locations of sounds produced by other musicians.

How effective are these products?

The earplug industry, together with health and safety researchers, have developed ways measuring earplug efficacy. They've come up with industry standards and protocols that are required to be built into the evaluation of a new earplug before it goes out to market. The commonly used protocol for testing earplugs is known as the Real Ear at Threshold (REAT) method. For the most part, earplugs are tested using this standard in nationally certified independent laboratories.

This subjective test protocol was developed over 50 years ago and remains an American National Standards Institute standard. It was never intended to be used to understand how earplugs work for musicians or in a musical context. Logically, it seems inappropriate because the testing does not involve music or musicians.

More importantly, the REAT protocol doesn't measure the way earplugs attenuate sounds at the critical frequency ranges that are the most dominant in [musical activities](#). In fact, if you think about the piano keyboard, the sound energy levels representing frequencies at the bottom third of the piano are not measured using these protocols. Nevertheless, those protocols are used to evaluate musician earplugs and for claiming how well they work.

What have you found regarding the efficacy of these musician-specific earplugs?

The debate about whether these earplugs are appropriate for musicians has been going on for a couple of decades. I've been involved in several of these debates and have tried to question the logic of continuing to use REAT to evaluate these earplugs.

When I started to look at the research that surveyed musicians about their experiences with these products, results were consistent across studies. Musicians reported that they experienced challenges while using these products. Some even reported that using these products was worse than the risk of damaging their hearing. The most common concern was the significant alterations to the sounds that they normally hear—which is counter to the claims made by the manufacturers of these products.

Those findings increased my concern for using the REAT protocol for assessing these products. These protocols are not effective if they aren't

accounting for these nuances that are showing up in these subjective reports by musicians.

I wanted to be more precise in understanding how the earplugs lowered sound levels at more discrete frequencies compared to the small number of frequencies used in the REAT Protocol. To do this, I worked with Aryn Amlani at the Texas Center for Performing Arts Health to create a research protocol that used KEMAR, which is an artificial head that has simulated ear canals. We were able to objectively test attenuation levels at 233 discrete frequencies across the full range of the musical experience.

Using the protocols we developed, we found that manufacturers were overstating the efficacy of their products. The custom fitted earplugs I mentioned earlier did not attenuate levels equally but were more effective in providing protection than the non-custom versions. But based on our testing, we found that the mass-marketed, non-custom earplugs provided very little protection.

If these plugs are not effective, how can musicians protect themselves?

As I mentioned earlier, we need to adopt better testing protocols for musician-specific earplugs. That is absolutely something that we can do here at Johns Hopkins.

Today, some audiologists claim that the best school music programs are where every kid is wearing hearing protection. Earplugs are pushed by some to be the primary, "go-to" response in ensembles across the world. Unfortunately, earplugs in general are very problematic. People just don't like them.

[The data I have collected on ensembles](#) show that ensemble sound energy is a direct reflection of what the teacher is doing. This suggests that there is a behavioral way to manage the amount of sound energy generated during playing activities. We can ensure awareness, knowledge, and professional competencies needed to manage musical behaviors so that levels are appropriate for human consumption.

Ensemble directors and conductors must be prepared to educate students about this from a young age. School directors need to know how to manage ensemble behavior and to train future professional musicians who are going out to the world with this kind of knowledge and expertise.

This conversation started after 3M settled a lawsuit with veterans over defective earplugs. Do you see a connection between what is happening in that sector and what is happening in the music industry?

Based on reporting I have reviewed, misleading claims were made about protection levels of combat earplugs. In addition to unexpectedly high prevalence rates for hearing problems among soldiers using these products, a whistleblower provided evidence demonstrating that some 3M employees were aware that these products did not work as claimed.

This parallels my experience on the music side. I have shown that while REAT is the standard test protocol for earplugs, it may not be a reliable protocol to consistently evaluate musician-specific earplugs. The leading manufacturers of musician-specific earplugs have marketed their products aggressively using testing results from REAT protocol, even after becoming aware of the protocol's limitations revealed in my research.

Some of the parties involved with this 3M story are directly connected (as co-patent holders of [musician's](#) earplugs) to those who tried to limit the influence of my earplug research. I have shown that earplugs designed for musicians don't perform as claimed, yet these companies are still selling these products to schools and musicians around the world.

We have a huge opportunity today to improve how these products are evaluated. One big conflict of interest that faces the industry is that most of the testing of these products is done in privately owned and operated laboratories. We need to re-examine that. I think that testing and evaluation of these products should be done in independently operated labs at research universities, like Johns Hopkins.

The industry also suffers from a lack of competition and innovation, which certainly hurts the end user. Universities like Johns Hopkins have access to some of the best scientists, musicians, engineers, and medical researchers in the world. One of the reasons I came to Hopkins was to access the interdisciplinary community to better address these problems. With the resources we have here, we may be able to develop more innovative and effective products that we can test using protocols that reflect real world use.

Provided by Johns Hopkins University

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