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Guest Blog

How Sound Can Be an Ally or an Enemy of a Healthy Brain

A new technique for measuring our neuronal response to sound is yielding both good news and bad news

- By Nina Kraus on February 23, 2017

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"It's so good to hear the sound of your voice." When talking to an old friend, it's our natural response. William Shakespeare reminds us in "Love's Labour's Lost" that, "A lover's ear will hear the lowest sound."

Sounds have a deep impact on our emotions and offer a wide spectrum of influences, as they can be loud, soft, interesting, annoying, important, distracting, soothing, infuriating.

Like electricity, gravity and air, sound is a powerful force. Yet, because it is invisible, we often remain largely unaware of the powerful influence sound has on our lives. Still, we have tools to protect and maximize its power.

A recent Centers for Disease Control study analyzing causes of noise-induced hearing loss, along with other recent studies about noise pollution due to environmental projects such as fracking, or the effects of loud city living on developing dementia, expose and remind us of the urgent and ongoing dangers of noise.

But sound is also crucial to our brain development in a positive way. There is ample evidence that playing an instrument has a positive impact on the developing brain. Speaking two languages, another form of sound enrichment, is good for attentional skills and multitasking and may prevent the onset of dementia.

Despite the power of sound in our lives, sound has a certain inscrutability. Due in part to its fleeting nature and its invisibility, we don't often stop to think about its impact on our brain. Its invisibility also causes us to struggle to describe sounds in contrast to the richly descriptive language we have at our disposal for the things we see.

Seen objects are tangible and persistent. In many cases, we can study them for as long as we like. Unless it is a moving object or an ephemeral action, we can use our eyes to analyze an object's size, color, texture, and shape, without having to rush.

We have concrete terms we can use to easily convey visual attributes using familiar language. If I used the words small, yellow, fuzzy, and spherical to describe an object, you might guess that the object was a tennis ball, or at least something that closely resembles a tennis ball.

A sound, by nature, though, is never static. It is always moving and so much tougher to describe. I might describe a sound as loud, high-pitched, and dissonant, and while it gives you a global sense of the sound, you wouldn't be able to begin to guess what I was describing. Is it a siren? A snatch of music? Squealing brakes? A bird squawking?

Nevertheless, our ears and, in particular, our brains do an amazing job of making sense of sound. By some measures, the auditory system is the most computationally intensive neural network. This is particularly true in terms of timing.

No other sensory system, vision included, can compare to the speed at which the auditory system processes the incoming soundscape. Much of this need for speed is due to the simple fact that sounds change over time.

Consider speech. The smallest acoustic unit of speech is a phoneme. For instance, the word “stream” has only one syllable, but it has five discrete phonemes. Change any one of them and the meaning is changed (street) or lost (spream).

In the [Auditory Neuroscience Lab] at Northwestern University, we have discovered, with a few electrodes and a few minutes, a way to capture the imprint that the sounds of our lives leaves on our nervous systems. This window into the finely tuned, speedy, precise auditory system has enabled us to demonstrate both the positive and negative impacts of our lives in sound.

Our newfound ability to capture these “brainwaves”—the brain’s reaction to sounds—has taught us that sound is separate from noise. The reaction to noise is a disorganized response. But the brain is so well tuned to speech, for example that babies begin to make sense of speech well before they develop language. They learn that certain sound combinations work or don’t work in their language within a couple minutes of exposure. The “brainwave” response to speech is so well-structured that you can actually understand speech in the brainwave if it is played back.

Noise is more pernicious than an in-the-moment nuisance. Even a modest level of noise, over a long enough period of time (e.g. beeping garbage trucks, hair dryers, air conditioners), can cause damage to the brain networks that extract meaning from sound. Many of us don’t even realize our brains are being blunted and our thinking impeded by this invisible force.

It seems most everyone is aware of the dangers that loud sounds can inflict on our ears. Yet long term exposure to sounds that are not loud enough for us to give them a second thought can cause permanent damage to the hearing brain. This is different from what we typically think of as “hearing loss,” which involves damage to the hair cells in the cochlea by noise, aging and certain drugs. Instead, it’s a disruption of some of the connections between the hair cells and the “higher” brain areas, which has been demonstrated in research on lab animals. So you might pass a hearing test, because the hair cells are still working, and some of the connections are still intact. Some of the connections that carry important information like speech, however, are missing

But we have available protections.

Ear protection such as the earplugs musicians use while on stage can stave off harm. The detriment of white-noise generators and apps probably outweighs any benefits. If possible, choose where you live wisely, based on noise levels. The constant low-level meaningless noise from the nearby highway or airport is chipping away at your brain’s ability to make sense of meaningful sounds like speech, and may hasten cognitive decline in old age.

Much as the presence of meaningless noise can cause problems, the absence of meaningful sound also leaves a mark on the ability to process sound. But there are distinct ways to tone and hone your listening brain.

You can learn a second language. The challenge of juggling two languages bolsters the auditory system and redounds to improvements in cognitive functions such as attention.

Another way to exercise your auditory brain is to play a musical instrument. This has a huge payoff cognitively and emotionally for children and adults alike. A few years of playing an instrument while in school sharpens the auditory system and can benefit language development in children. And this benefit lasts a lifetime.

In my laboratory, when I see a computer screen displaying someone's brainwave, I can usually guess whether they are a musician or not based on the rich, clean quality of the musician's brain signature.

At the other end of the spectrum, my lab works with children who grow up in noisy environments and receive little linguistic enrichment. And, sadly, I can spot that signature too. Yes, sound, for better or worse, is that powerful.

ABOUT THE AUTHOR

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