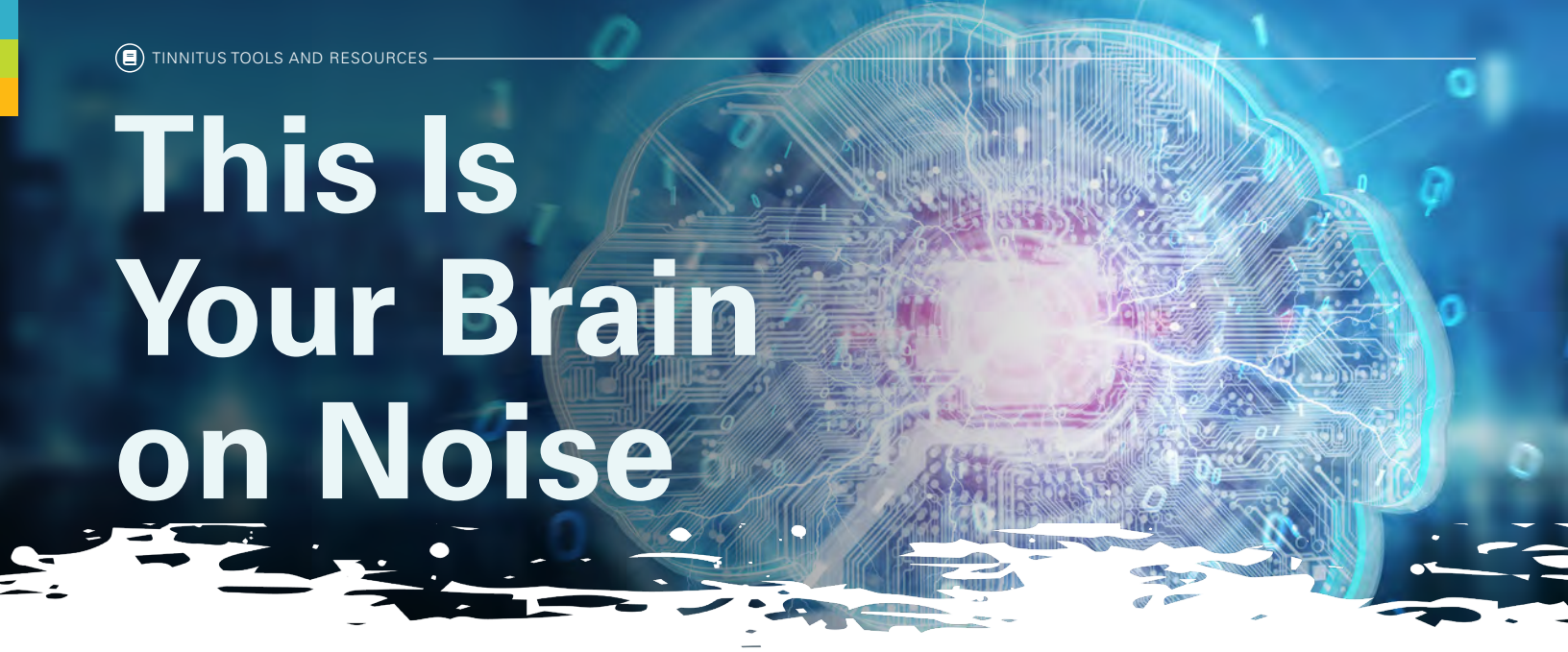
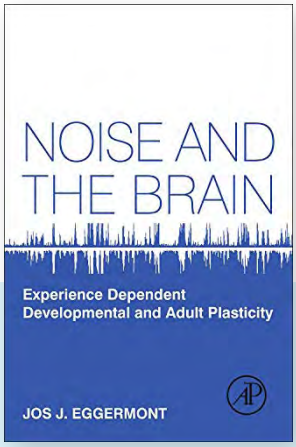
This Is Your Brain on Noise





Book Review
Noise and the Brain: Experience Dependent Developmental and Adult Plasticity

Title: *Noise and the Brain: Experience Dependent Developmental and Adult Plasticity*
Author: Jos J. Eggermont
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By Jan L. Mayes, MSc

Dr. Jos J. Eggermont, auditory system researcher and emeritus professor at the University of Calgary, is highly qualified to write about unhealthy noise in our "modern world of excess sound." *Noise and the Brain* is his in-depth, well-written book on the subject.[1] While the book was published in 2013, it remains an excellent resource for understanding auditory brain health.

In it, he reviews a wide body of scientific research to prove that noise damage extends far beyond inner ear–related hearing loss. Noise causes auditory nerve degeneration and auditory brain changes, also called central auditory processing disorders, which are linked to tinnitus, hyperacusis or decreased sound tolerance, and difficulty understanding speech in noise. Auditory nerve degeneration can progress for up to one year after a noise exposure.

Each chapter has its own reference list, typically 80 to 100 key scientific studies, some dating back decades. The research includes human trials in children and adults and animal models using intentional noise exposure.

Eggermont considers noise a "life span" problem stemming from environmental, music, recreational, and work exposures and urges better awareness of moderate to loud noise risk to the auditory brain, especially in newborns, children and teens. The human auditory system is not fully developed at birth and does not reach mature auditory processing performance until a person is 15 to 20 years old. He shows that into the teen years, children are at higher risk from noise exposure while their auditory systems are still developing. Hence, noise that may not affect adults can cause permanent auditory damage in developing ears and brains.

Loud noise examples in the book include personal listening devices, but Eggermont emphasizes that even moderate levels of "noise or hum" should be considered high risk for young people whose auditory systems are still developing. Noise causes permanent "maladaptive" brain changes even when the level is "non–hearing loss causing." Eggermont shares examples of hum-type environmental noise, including in neonatal intensive care units, from road traffic, from aircraft and at airports, and the low-frequency noise from wind turbines.

When sound is loud enough to cause hearing loss, noise causes "aberrant brain changes." While hearing loss from noise-damaged inner ears is fairly well recognized, *Noise and the Brain* highlights the fact that individuals exposed to noise can develop noise-induced auditory processing disorders like tinnitus, hyperacusis, and problems understanding speech in noise even without any hearing loss. These dysfunctions typically develop before any measurable hearing loss can be seen on a standard audiogram. The chapter on tinnitus is aptly titled "Noise in the Brain."

Noise and the Brain includes several chapters that focus on other negative consequences of noise exposure. Ambient noise causes speech communication breakdowns for children and older adults. Nonauditory noise effects, similar to those seen with tinnitus, include annoyance, stress, and impaired sleep. Additional noise-induced problems include hypertension or high blood pressure, decreased school performance, and behavior and attention problems. Eggermont identifies that hyperacusis is most sensitive to environmental noise.

The author concludes that noise control is needed, but emphasizes that noise limits established to prevent hearing loss are not low enough to create "brain-safe" environments for the public. He includes several examples of noise level risk that clearly debunk the "85 dB is safe" myth. The auditory injury threshold is between 75 and 78 decibels (dB) average exposure, regardless of listening time. Exposure to 76 dB for eight hours is associated with noise-induced auditory brain changes, stress, and hypertension. Auditory processing disorders can develop from noise exposures between 65 and 80 dB, and the effective quiet level to rest the auditory system between noise exposures is at least 55 dB. Because auditory brain disorders can develop without any related hearing loss, standard threshold audiometry is not a good indicator of safe exposure levels.

I started out as an audiologist in the 1980s and specialized in noise-induced auditory damage over most of my career. I've always had an interest in central auditory processing disorders, but in school I had only one course on brain anatomy and function. Some parts of *Noise and the Brain* were difficult for me to understand, mainly the sections describing typical versus disordered brain anatomy and function. Figures, graphs, tables, and brain scan images were helpful in explaining the text.

I think *Noise and the Brain* succeeds in proving noise-induced auditory damage is far worse than suspected in the past. A key takeaway is that a lifetime of loud noise exposure causes auditory processing problems in the brain in addition to permanent progressive hearing loss. A bigger takeaway is the high risk from noise exposure during infancy through the teen years. Even moderate-level noise exposure can cause brain changes linked to auditory processing disorders, without any hearing loss.

Eggermont recommends using auditory processing tests, such as speech-in-noise performance, because standard audiograms are not sensitive to auditory brain health. Based on my experience, I agree that a battery of tests is useful for identifying noise-induced auditory problems. I would add extended high-frequency audiometry above 8,000 Hertz and cochlear function testing (e.g., otoacoustic emissions), which are considered sensitive to early noise-induced hearing damage.[2] Consistent age-appropriate definitions of tinnitus and hyperacusis are also essential to further research on noise and auditory system health.[3]

As Eggermont points out, we don't know everything there is to know about how our auditory system works or what noise levels are completely safe for total auditory health. Nevertheless, I highly recommend *Noise and the Brain* as an excellent evidence-based reference volume or textbook.

This is an advanced science book that would likely interest anyone who already has some understanding of the brain or auditory system, including researchers, otologists or ear, nose, and throat physicians, audiologists, speech-language pathologists, psychologists, physicians, educators, and other specialists, as well as members of the public who are interested in the science. Public health authorities or noise control decision makers should also find this book useful.

Jan L. Mayes, MSc, has had tinnitus for more than 30 years. She is an award-winning author of nonfiction hearing health books. As a newly retired audiologist, Mayes continues to write about tinnitus, hyperacusis, and community noise impact on disability access, communication, and hearing wellness. In her spare time, Mayes enjoys writing dystopian fiction. To learn more, visit her website: www.janlmayes.com

1 J. J. Eggermont. (2013). *Noise and the brain: Experience dependent developmental and adult plasticity*. Academic Press.
2 M. Pienkowski. (2021). Loud music and leisure noise is a common cause of chronic hearing loss, tinnitus and hyperacusis. *International Journal of Environmental Research and Public Health, 18*(8), 4236. https://www.doi.org/10.3390/ijerph18084236
3 S. N. Rosing, J. H. Schmidt, N. Wedderkopp, & D. M. Baguley. (2016). Prevalence of tinnitus and hyperacusis in children and adolescents: a systematic review. *BMJ Open, 6*(6), e010596. https://www.doi.org/10.1136/bmjopen-2015-010596