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MIND Guest Blog
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Night Noise: What a Sleeping Brain Hears

By Dorian Rolston on June 17, 2013

Earlier this year, a Kickstarter campaign for a documentary film called "In Pursuit of Silence" raised \$35,371, exceeding its goal in just a few weeks. On a crowdfunding platform where a new film proposal can pull in nearly 100 times that amount--for Zach Braff's follow-up to "Garden State," precisely \$3,105,473--the financing feat was modest. Still, [hundreds of contributors shelled out cash](#), remarkably, for nothing but onscreen peace and quiet. By "exploring the value of silence, our relationship with sound, and the implications of living in a noisy world," promised Patrick Shen, the documentary's director, viewers could indulge in 80 minutes of quiescence. And, for over 35 million Americans suffering from hearing loss, toiling in urban cacophonies roughly 1 decibel louder every year, perhaps that was worth the price of admission. "Watching a film is often very noisy and stimulating," Shen told me. "By occasionally slowing down the pace--in the form of silent pauses and extended experiential vignettes--I can induce a sense of silence." That, anyway, is the plan. For the moment, Shen says of those "places where we can gain a sense of silence or calm," he is still very much in pursuit. "I have no idea where those places are." Neither, apparently, does the World Health Organization. In a 2011 publication, ["Burden of disease from environmental noise,"](#) a WHO-led research team analyzed data from numerous large-scale epidemiological studies of environmental noise in Western European countries within the past 10 years. The studies looked closely at planes grumbling, trains whooshing and whistling, and automobiles bleeping, and then traced links to cardiovascular disease, cognitive impairment in children, sleep disturbance, tinnitus, and relentless annoyance.

Poring over these data, the WHO team calculated the disability-adjusted life-years or DALYs--in essence, healthy years of life--lost to "unwanted," human-induced dissonance. The toll: not counting industrial workplaces, at least one million DALYs each year. "There is overwhelming evidence," they conclude, "that exposure to environmental noise has adverse effects on the health of the population." To Americans, the findings should not come as a complete surprise. [As early as 1930](#), the New York Noise Abatement Commission warned that prolonged exposure to loud noise not only damages the ears but also dampens workplace productivity, interferes with child development, disrupts sleep, and generally creates stress. (While the commission is now defunct, Bloomberg is [cracking down again](#).) In 1978, then Surgeon General William Stewart declared something of a war on noise--or cautioned, at very least, that noise was at war on us. "Calling noise a nuisance is like calling smog an inconvenience," he said. "Noise must be considered a hazard to the health of people everywhere." Perhaps unsurprisingly, such concerns were easily dismissed. That even the thunderclap of an engine back-fire or the panoramic wail of sirens--among the most bristling jingles of modernity--might not just startle but sicken, posing a host of threats to the citizenry's health, amounted to little more than fearmongering. (Columnist James Kilpatrick famously deemed federal concern over noise ["bureaucracy gone berserk."](#)) Environmental noise, if a nuisance, was simply part of life in the city, whose dwellers may have been somewhat more irascible, less patient, but certainly not ill. Today, though, more sophisticated brain activity monitoring can detect consequences beyond diminished quality of life.

A city's soundscape appears to be setting off the body's acute stress responses that raise blood pressure and heart rate, mobilizing a state of hyperarousal. Preliminary results from a study of six European countries, included in the WHO publication, attributed to noise nearly 1 in 50 heart attacks across Western Europe. The panel ultimately ranked traffic noise second among environmental threats to public health, just behind air pollution, and affirmed the threat to be, unlike

that from exposure to second-hand smoke, dioxins, or benzene, rising inexorably. Noise pollution "is considered not only an environmental nuisance," WHO has warned correctively, "but also a threat to public health." All of which raises the question: If the world is so much noisier, then why is no one listening? The insidiousness of noise is not only that it kills, but that it does so quietly.

According to the WHO publication, the majority of lost DALYs can be traced to noise we aren't even aware of hearing. The real danger, it appears, is from whatever drifts into our ears undetected--during sleep. (Though [numerous other non-auditory effects](#) have been documented.) "Sleep disturbance accounts for more than half of the overall noise effect--and more if you ignore annoyance," says Dr. Mathias Basner, assistant professor of sleep and chronobiology in psychiatry at the University of Pennsylvania School of Medicine, referring to the WHO publication. "Impact of noise on sleep disturbance is regarded as one of the most detrimental environmental effects of noise." As we nod off, our perceptual faculties become attuned to the environment in such a way that, unlike during the day, can't be consciously managed. The mind is rendered vulnerable to whatever stimuli happens to filter through, and, since the eyes can be shut, that happens to be through the ears.

This receptivity was undoubtedly adaptive for our ancestors, alerting them to predators lurking in the darkness. But for us today, the WHO reports, it "constitutes a health issue." "The permanently open auditory channel," [writes Barbara Griefahn in *Noise & Health*](#), "and the ability of the brain to process incoming acoustical stimuli even while asleep and to respond adequately is the essential precondition for noise-induced sleep disturbances, which are regarded as the most deleterious effects of noise." Interrupting sleep--and subsequently sapping its restorative power--can impair psychomotor skills, memory, creativity, and judgment, among other things. Yet, much of that impairment has been evaluated by self-report, a method which "may not reflect the total impact of nighttime noise on sleep," WHO admits. Capturing the full extent of the damage requires peering inside the sleeping brain. Orfeu Buxton, an assistant professor in the division of sleep medicine at Harvard Medical School, and associate neuroscientist in the division of sleep medicine at Brigham and Woman's Hospital, is in the vanguard of this growing research movement. Recently, in his sleep laboratory, he put a group of healthy volunteers to sleep and then monitored their brain activity as a surround-sound system played a sequence of 10-second clips of hospital noise: talking, ringing, flushing, beeping; door-swinging, overhead-paging, machine-dispensing, laundry-cart-rattling; an emergency helicopter whirring above, city traffic flowing below. On the EEG recordings, brain waves appeared, as predicted, to gently meander along as the volunteers fell asleep, and then to spike in jagged, wake-like patterns of neural activity, when each of these single clips played.

Curiously, though, analysis of the recordings showed that the most arousing noise [could be predicted by type](#). During non-rem sleep, a clear hierarchy of types emerged--topped by what has become ubiquitous as a protective measure in hospital wards, electronic noise. The digital din of hospital equipment, even at levels as faint as a whisper (about 40 decibels), aroused brains 90 percent of the time during the lighter, non-rem stage 2 of sleep that comprises roughly half the night for adults; at the level of conversation (50 decibels), it was nearly impossible to sleep through. The 70-decibel whir of a chopper, by contrast, was arousing only 60 percent of the time. (Bursts of hypothalamus-generated neural oscillations, known as sleep spindles, are considered signs of sound sleep--more spindles, more snoozing--and, in another study, were found to offer [biomarkers of this vulnerability to noise](#).) "Think about the point of these noises," Buxton urged. "It's to alert the staff, who are down the hall. So the patient is sort of collateral damage." "What those data are telling us," Buxton explained, "is that short, sharp, rapidly-accelerating to peak kind of noises that are intentionally alerting are the single most arousing. Those noises might reflect something coming at you, which your brain's state of 'threat vigilance' picks up, becoming aroused and potentially fully awakened." Even if brain arousals don't jostle someone awake, they do disrupt sleep--in ways that, akin to the fight-or-flight response, are known to generate cardiovascular activation, such as

increased heart rate and blood pressure. Scientists monitoring acoustics in one major urban hospital found average nighttime noise levels climbed steadily from 42 dBA, some decades ago, to more than 55 dBA, in 2005. More recently, peak levels in the ICU have been recorded as high as 67 dBA--over twice the level recommended for patient rooms by the WHO. Some noise, as *The New York Times* reports, even "[borders occasionally on deafening](#)," costing them sleep, raising blood pressure, and requiring 25 percent larger doses of sedative to be administered. Such disturbances have caught the attention of administrators and care-providers, not to mention patients, at hospitals, where it is becoming increasingly difficult to get a good night.

Patients answering a recent national survey for the *New England Journal of Medicine* identified noise levels as the quality-of-care factor most needing improvement. In 2010, the "Guidelines for Design and Construction of Health Care Facilities" incorporated, for the first time, [explicit acoustic standards](#).

[/caption] "I find our current environment and atmosphere highly toxic," Buxton said. "We are constantly being pattered by sounds, many of them alerting--alarms or attention-getting in an obnoxious way that activate your response to stressors." Which is why, he added, "I greatly appreciate silence and natural noises." Shen, for his part, remains ever in pursuit of them. "There's a quality of sound we're looking for when we say we're seeking silence," he says. "The sound of birds chirping, research shows, is very calming and soothing to us. If you think about our evolutionary past, that sound would be a signal of safety, indicating that the danger is gone and we are now safe to leave our caves." If the night noise that invades our sleep is any indication, abiding in our caves--or, as Shen intends, donning the cavernous protection of noisecancelling headphones--sounds more or less right.