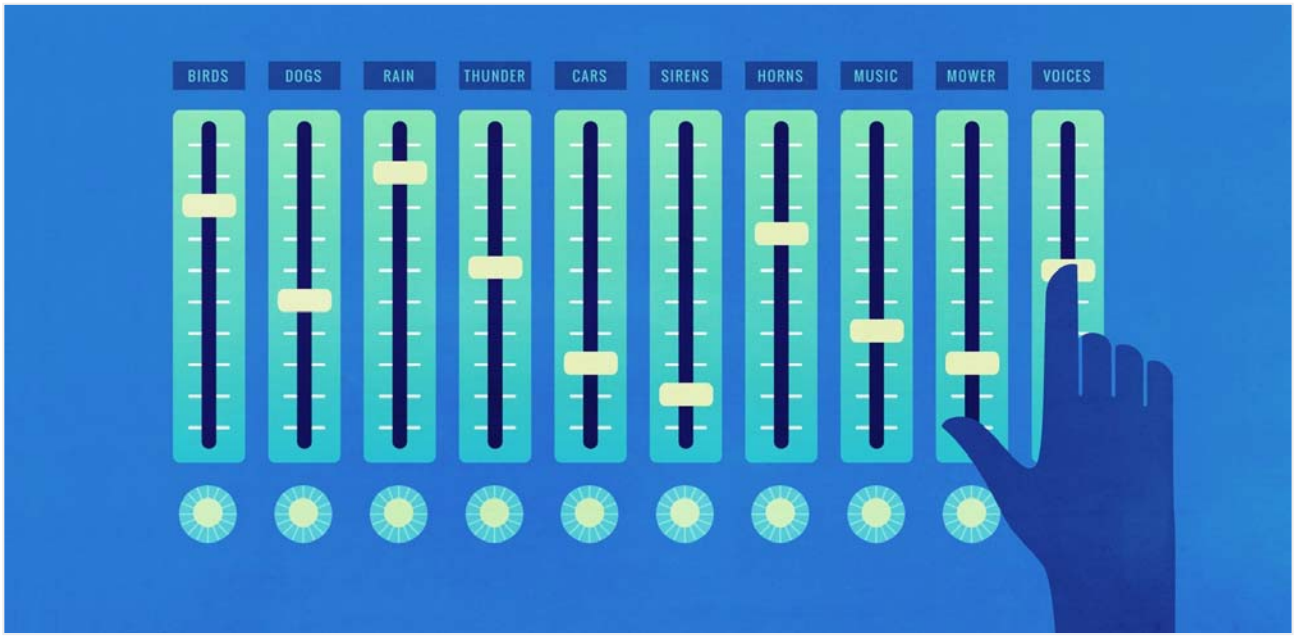
The Atlantic

Sonic Boom

How digital technology is transforming our relationship with sound



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MAY 1, 2014 | TECHNOLOGY

In late January, a group of musicians, led by the trombone player Glen David Andrews, paraded through the narrow hallways of New Orleans' City Hall and into the chamber of the City Council. They played snare drums and horns, cymbals and saxophones, trumpets and tubas. They danced. They sang a song called "Music Ain't a Crime." They held signs reading "WE WILL BE HEARD."

Andrews and his fellow musicians were protesting a proposal that would re-imagine noise regulations for the city's storied Bourbon Street. Sound in the area has been a matter of law since 1831, when the young city adopted an ordinance—one "concerning Inns, Boarding-houses, Coffee-houses, Billiards-houses, Taverns, Grog-shops, and other houses with the city of New-Orleans"—that forbade "cries, songs, noise or ... disturbing ... the peace and tranquility of the neighborhood."

Since approximately 1831, the precise definition of "peace and tranquility" has also been a matter of controversy. There are, particularly when it comes to controlling the din of "the biggest disorganized street in the whole country," competing constituencies: tourists, residents, bar owners, professional musicians, less-professional musicians. There are, noise-making and personal expression being intimately acquainted, First Amendment considerations at play. There's money at stake. There are cultural sensitivities to be respected and navigated.

"You have to do it very carefully," says David Woolworth, a principal at the firm Oxford Acoustics, "because people take it really personally when you go after their music."

A sketch from *Frank Leslie's Illustrated Newspaper* shows the streets of New Orleans during the 1867 Mardi Gras festivities.

One of Oxford Acoustics' clients is NASA, which the firm worked with to shape the sound of rockets. Another is the New Orleans City Council. For the past three years, Woolworth has been gathering data about Bourbon Street's sounds, in the service of a potential update to the city's current noise-control regulations—regulations, many argue, that are outdated and poorly enforced. He's been doing that by taking careful sonic measurements of the good times as they roll, at different spots, and at different hours of the day and night. The goal? A detailed and accurate soundscape of a city known for its noise.

"It may be the most challenging thing I've ever faced," Woolworth told me. "How do you manage the whole thing without crashing the party?"

The proposal that resulted from Woolworth's work includes, among other things, a new requirement to measure "C-weighted" sounds—the lower frequencies (produced by subwoofers, for example) that can vibrate through neighborhoods and be particularly disturbing to human ears. It would limit the bass noise emitting from inside a club to no more than 97 decibels (roughly the level of a power mower), at all times of day or night; require sound measurements to be taken 5 feet from a building if the business's doors and windows are closed; and restrict amplified sounds on public streets to 91 decibels, measured 3 feet from the source. It would decriminalize noise law violations, making them punishable by nothing more than a civil fine. It would also, perhaps even more significantly, shift most of the responsibility for enforcement of the noise law from the police to the city's Health Department.

"People take it really personally when you go after their music."

Woolworth's proposal came to a vote last Thursday. It lost. For now, anyway, Bourbon Street's noise will remain as it's been. But Woolworth's work is more than

political, he argues, and about more than noise regulation alone. “It's okay that it didn't make it on this round,” Woolworth told me, “because there's plenty more work to be done.”

And it’s work that hints at questions that are much broader, and much older, than Bourbon Street itself. How do you design cities and civic spaces in ways that account for people’s varied reactions to sound itself? Where does “sound” end, and “noise” begin?

What Is ‘Noise’?

Sound, at its most basic, is simply a wave of pressure and displacement—a mechanical vibration that bounces around the surfaces of the world until it alights on an obliging eardrum. Some sound waves are audible to us; many are not. Some sound waves are pleasant to us; many are not. There are subtle subjectivities built into the act of listening. As Emily Thompson, a Princeton professor who studies the cultural history of sound, put it to me: “One man’s noise is another man’s music.”

The problem with this otherwise delightful diversity is that sound, whatever a single mind makes of it, is generally shared. (“Blindness separates people from things," Helen Keller once remarked, while "deafness separates people from people.”) Long before homes were built around Bourbon Street, human dwellings

were designed around shared auditory experiences. The Huns arranged their pop-up towns in ways that would ensure human voices could be heard in a kind of relay: empire by way of earshot. Plato limited the size of his model Republic to 5,040—the number of people that could have been addressed, at the time, by a single orator.

"The uproar of mankind is intolerable," complained a god in the ancient *Epic of Gilgamesh*.

In Medieval Europe, civic life radiated out from the bells that were situated at town centers. People were attuned to the instruments' varied rhythms—sound-based precursors to Morse code—which called them to market, beckoned them to prayer, and announced the beginning and ending of curfews. Death knells signaled whether the departed person was a man, woman, or child. As John Huizinga puts it in his history *The Waning of the Middle Ages*, the sounds of bells "rose ceaselessly above the noises of busy life, and lifted all things unto a sphere of order and serenity."

But as long as there have been communal sounds, there have also been attempts to regulate them. *The Epic of Gilgamesh*, one of humanity's oldest surviving works of literature, describes an ancient noise dispute. "In those days," the poem declares ("those days" being the 18th century BC),

> the world teemed, the people multiplied, the world bellowed like a wild bull, and the great god was aroused by the clamor. Enlil heard the clamor and he said to the gods in council, "The uproar of mankind is intolerable and sleep is no longer possible by reason of the babel."

The divine council's reaction to Enlil's complaints? "The gods agreed to exterminate mankind."

Julius Caesar's approach, fortunately for his subjects, was less extreme. In 44 B.C., he made the following declaration to limit the thunderous noise of wooden wheels

on stony streets:

> Hence-forward, no wheeled vehicle whatsoever will be allowed within the precincts of the city, from sunrise until the hour before dusk.... Those which shall have entered during the night, and are still within the city at dawn, must halt and stand empty until the appointed hour.

By the 13th century, towns in England were restricting blacksmiths to specially designated areas (the crash of the blacksmith's hammer being, one historian notes, "probably the loudest sound a solo human hand ever produced"). Under Elizabeth I, two different Acts of Parliament addressed a common civic annoyance: street music.

In *The Enraged Musician*, a 1741 engraving by the English artist William Hogarth, a classical violinist is disturbed by the noises of London.

Those acts, being extremely difficult to enforce, proved largely ineffective. Several centuries later, the streets of London were as loud as ever. In the mid-19th century, a doctor wrote to *The Times of London* to complain about, among other things, "the early organ-grinders, collectors of hares' and rabbits' skins, sellers of watercresses, [and] the inevitable dustman"; paper boys yelling out the news; musicians disturbing the peace; cab drivers yelling at each other from across the street; and drunkards "who choose to sing and holloa up and down our streets and squares."

In 1864, Michael T. Bass, a British member of Parliament, received a plaintive missive signed by Charles Dickens, Thomas Carlyle, Alfred, Lord Tennyson, Wilkie Collins, and the painters John Everett Millais and Holman Hunt:

> Your correspondents are, all, professors and practitioners of one or other of the arts or sciences. In their devotion to their pursuits—tending to the peace and comfort of mankind—they are daily interrupted, harassed, worried, wearied, driven nearly mad, by street musicians. They are even made especial objects of persecution by brazen performers on brazen instruments, beaters of drums, grinders of organs, bangers of banjos, clashers of cymbals, worriers of fiddles, and bellowers of ballads.

Charles Babbage, the eccentric genius who would invent the world's first computer, followed up with a separate note. "One-fourth part of my working power has been destroyed by the nuisance against which I have protested," the mathematician complained, having done the math on the matter.

Adding to the anxiety was a growing fear that a louder world was a more dangerous world. In his 1713 book *Diseases of Workers*, the Italian physician Bernardino Ramazzini made the first connection between industrial machinery and deafness; in 1890, Thomas Barr's survey of hearing loss among workers in steam boiler factories led to a new awareness of noise-induced deafness, or "boilermakers' disease."

"... brazen performers on brazen instruments, beaters of drums, grinders of organs, bangers of banjos, clashers of cymbals ..."

There were more psychological concerns, as well: Friends of the illustrator John Leech attributed his death in part to the frayed nerves brought on by a constant thrum of street noises. The medical writer Edwin Ash suggested that the industrial age and its background noise had created a new disease. He called it "Londonitis."

The United States, meanwhile, had its own problems with noise. In her MacArthur-funded "Roaring Twenties" project, Princeton's Emily Thompson made an effort to recreate the soundscape of New York City as people experienced it during the late 1920s and early 1930s. As part of her research, she mapped some of the complaints sent to New York's Noise Abatement Commission during those years. Included among them?

- "Fog Warning Siren, Immigration [Ellis Island] Ferry Boat Dock"
- "Radios at 131 West 94th Street and 130 West 95th Street; Singer at 146 West 95th Street; Barking Dogs at 146 West 95th Street and 135 West 94th Street; Drinking Party at 135 West 94th Street; and Newsboys Crying Headlines"
- "All-Night Pumping at Construction Site, Southwest Corner of West 63rd Street and Central Park West"
- "Loud Music from Nighttime Rooftop Dances, 97th Street at Amsterdam Avenue"

There was also the man who called in to complain about the racket made by the Colonial Pickle Works Factory, situated near his home in Brooklyn. According to the records, his name was Mr. Schmuck.

How Is the Noise Loud?

To those of us living in the 21st century, the New Yorkers' complaints about Amsterdam Avenue flappers—or even, for that matter, the ancient gods' decision to kill off humanity for partying too loudly—might seem only slightly extreme. The insistent peal of the 4 a.m. car alarm; the booming surround-sound of the movie in a theater; the twitchy ping of the just-delivered email; the casual leaking of that *unz-unz*-y Ke$ha song through a neighbor's wall ... these are sounds that we alternately enjoy and endure as the transaction costs of technological advancement.

And our ability to measure these sounds—our ability to understand them, mathematically as well as emotionally—is evolving, as well. The development of the decibel, spurred by the electrical-current work of Bell Telephone Laboratories in the 1920s, gave scientists the ability to quantify, via a single standard, the world's noises. Noise regulation finally had numbers behind it. New York City established its Noise Abatement Commission in 1929.

The maximum volume the average human voice can reach is around 80 decibels, as heard from a distance of a few feet. This is, not coincidentally, just under the 85 decibels or so that can, over long periods of exposure, compromise the delicate infrastructure of the human ear. Our hearing, like every other sensory mechanism we use to move through the world, relies on a set of finally calibrated instruments—the products of our longstanding relationship with our sonic environments. Our capacity to speak has co-evolved with our capacity to hear. As the

pioneering acoustician R. Murray Schafer put it in his 1977 book *The Soundscape: The Tuning of the World*: "God was a first-rate acoustical engineer."

Living near major roads in New York or London, studies have suggested, can increase people's risk of stroke and lower their IQ scores.

Human technology has outpaced human evolution in this regard; our bodies are navigating a world that we have made louder than our genes anticipated on our behalf. "Intense noise," researchers have found, "can cause headaches, nausea, sexual impotence, reduced vision, and impaired cardio vascular, gastrointestinal, and respiratory functions." Living near major roads in New York or London, some studies have suggested, can increase people's risk of stroke and lower their IQ scores. Music heard at top volume, streaming into our ears through buds and phones, has contributed to the rise of sociocusis, or non-industrial hearing loss. In 2012, research conducted by *The New York Times* found that city bars regularly reached decibel levels so high that they violated federal workplace safety standards. This was a more subtle version of a declaration made by a sound engineer in the 1920s: that simply standing in Times Square, with its din of music and transportation and construction, would be enough to "deprive us of 42 percent of our hearing."

In extreme cases, people have harnessed this destructive power to cause intentional harm. During the Iraq war, U.S. troops realized this sonic vision tangentially: They blared Metallica's "Enter Sandman"—and, worse, the "I Love You" song from *Barney and Friends*—to prisoners in an attempt to "break" them before interrogations. British naval officers have been known to broadcast Britney Spears songs to deter attacks from Somali pirates. (It's an effective ploy: "As soon as the pirates get a blast of Britney," one noted, "they move on as quickly as they can.") A Ukrainian town recently muffled Russian propaganda with the sonic stylings of Cher.

Far more often, though, the damage inflicted by noise is an accidental byproduct of other people's work or recreation. And this is where the challenge comes in. For experts settling noise disputes, the question is not simply, "How loud is the noise?" but "*How* is the noise loud?"

Outdoor concerts have long been a source of summer enchantment—and public dispute. Above: New Yorkers (including then-Congressman Ed Koch) gather in 1977 to hear James Taylor perform in Central Park. (New York City Department of Parks and Recreation)

In Atlanta, the Chastain Park Amphitheater has been grappling with similar tensions to the ones New Orleans is facing. The amphitheater, which seats some 7,000 people, sits adjacent to a wealthy enclave. When it is full, Chastain is loud. But it's loud with different kinds of music: sometimes, it'll be symphonies. Sometimes it'll be rock. Sometimes it'll be hip-hop. Sometimes it'll be jazz.

In the early 2000s, an acoustics engineering firm called Acentech worked with the City of Atlanta to develop noise regulation standards for Chastain and its immediate surroundings. Given the many groups who have stakes in the venue's volume—the residents, the concert-goers, the City of Atlanta—Acentech worked to come up with an ideal decibel level. An ideal that takes into account the particular

sensitivities of human ears and human minds. “If you just look at sound levels,” says Carl Rosenberg, a principal at Acentech, “you're going to get contours, and you'll get a print-out, statistical definition—but it doesn't tell you what something sounds like to the human brain and human perception.” And legal regulations, of course, are primarily concerned with human perception. As Robert Berens, a longtime supervisory consultant at Acentech, puts it, "How do we come up with a metric so we can hold the venue's feet to the fire?"

In noise disputes, says an acoustician, the most realistic goal may be "equally pissing off both sides.”

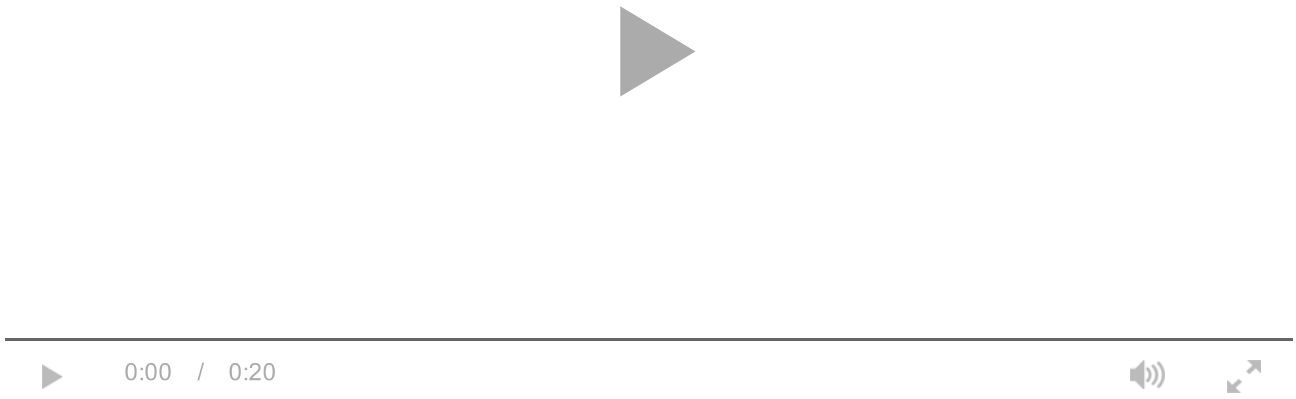
To do that, Berens and his team monitored sound levels during 17 different Chastain concerts, across a range of musical genres. They monitored community sound levels—ambient noise, essentially—at 25 locations, nine of which involved measurements made simultaneously both inside and outside of homes.

Their findings? Chastain residents found low-frequency sound to be much more disruptive than high-frequency sound. And only a small proportion of the Chastain concerts resulted in any significant community annoyance at all. Berens and his team, after examining their data, proposed a metric that would address those nuances. It’s a highly specific standard, but it was willed into being by the recognition that human reactions to sound can’t be fully standardized. Berens jokes that, in regulating noises, the most realistic goal may be “equally pissing off both sides.” In other words, “nobody's going to be satisfied” ... but “maybe both parties will be equally perturbed.”

The Sound of a Washing Machine

Which brings us back to noise’s pesky subjectivity. “If you can measure it, you can make it be quieter than some regulations say,” Berens says. “But that doesn't necessarily correlate well with whether people are annoyed by it."

We're standing in Acentech's offices in Cambridge, Massachusetts, in the middle of a reverberant room—a chamber, about 20 feet long by 15 feet wide by 10 feet high, that exists for pretty much no other purpose than to encourage echoes. The chamber's walls and ceiling are composed of concrete blocks; those blocks have been coated multiple times with thick white paint to seal their pores. This means, says Berens, that "there's no place for the sound to go—nothing to suck it up."



The room's properties help Acentech's team of 50 consultants isolate the unique sounds that are generated by particular objects. Those may include vacuums. They may include fans. They may include hair dryers. Whatever the products, the noises they make can be hard to determine in a less echo-y space. "This room is used to figure out how loud something actually is," Berens tells me, "and how much power it radiates."

But the room couldn't do that very precisely without the help of computer software. Acoustical engineers, with Acentech at the forefront, are developing a new technique, auralization, that allows for the creation of sound models based on digital renderings. "So you listen to a model of a room," Rosenberg tells me, "and you feel like you're in the room." Before digitization was an option, engineers relied on analog decibel readers that made it harder to isolate the different components of

a sound. Now, though, Acentech and fellow firms are applying the logic of big-data analysis to the sonic vibrations that permeate our shared spaces. Which allows them to offer better answers to some longstanding design questions: What's the ideal volume for a movie playing in a theater? What's the best placement for wind turbines? How do you design coffee shops that create pleasant, but not disruptive, dins? How do you build a blender that sounds powerful, but not gratingly so?

Some washing machines are designed to have more rumble than whine. Others have more *slosh* than *swoosh*.

In part, that requires the breaking down of sound—or, more accurately, what we humans interpret as "sound"—into its constituent elements. Whine. Roar. Rattle. Hum.

The sounds you hear when you do your laundry—the whirring of the motor, the whirling of the clothes, the swishing of the water, the sloshing of the soap—are the products not just of engineering, but also of a series of careful design decisions made by the machine's manufacturer, often with the help of firms like Acentech. Some machines have more rumble than whine. Others have more *slosh* than *swoosh*. Each model combines these components slightly differently, imprinting a household with its own distinct sonic signature. The noise of a washing machine is, in a sense, a marketing tool. Sound sells.

A vintage Hoover ad invites consumers to choose between "powerful suction" and "triple-action" cleaning. Today's manufacturers can carefully engineer the sounds of an appliance to signal what it can do.

David Bowen, the director of Acentech's Noise and Vibration Group, explains all this to me as he clicks around two large computer screens. "You can sort of take apart the appliance," he says. "For a vacuum, for example, there are a lot of things that make noise. There might be a sort of whooshing sound from the air, there might be a high-pitched sound from something in there." There might be a rotating beater brush for the carpet—yet another noise source.

Bowen and his team, from there, use a process that involves focus groups—subjective jury listening, they call it—to figure out people's emotional reactions to sound. Part of their work involves remixing the sound elements of various products. Another part involves understanding what's going on in the listeners' minds as they hear those products at work. "The question," as Bob Berens explains it, "is how to quantify those different elements of the sound and listeners to try to get things they don't know they're saying."

"How do we make the cheap Japanese car sound like the more expensive German car?"

So if you make vacuums, you probably want a roar that conveys power but isn't *so* powerful as to be disruptive to the home environment. If you make dishwashers, you probably want a hum that is relatively quiet, but also loud enough—humming

enough—to be soothing. If you make motorcycles, you want an engine, probably, that *vroooooms* as plaintively as possible. (Its success in this area led Harley-Davidson to attempt to patent the signature chug of its V-twin engine. That attempt was, alas, less successful.) And if you make cars, you want, among other things, a door that slams with a thud that indicates substance and maneuverability at the same time.

“A Mercedes,” Berens says, “has got a "*twuuuunk*—”

“—a really solid feel,” Bowen says.

Whereas, Berens continues, a less well-made car, a Japanese or Korean car, might have a "*dwiiiink*."

So the question is, Berens says: “How do we make the cheap Japanese car sound like the more expensive German car?"

“Without,” Bowen says, “actually *making* an expensive German car?"

For a car door, this might mean playing around with the dimensions of the steel, with the air inside the door panels, with the spring elements in the door’s hinges. “So if your car door falls off,” Berens says, glancing at Bowen, “it’s his fault.”

'Hear What You Want'

The tagline from a recent ad for the ubiquitous Beats by Dre headphones is "Hear What You Want." This is quietly revolutionary. Today, for the first time in human history, we are not only able to break down the components of what makes a noise noisy; we're also able to control sonic inputs at the level of the individual human. We're able to customize our lives with music and podcasts and videos that stream to our ears alone. These playlists are often so intimately calibrated to our desires that even the errant sight of someone else's soundtrack displayed on a screen—that guy on the bus clicking on to Mumford and Sons' "I Will Wait"—can seem like a fairly extreme violation of privacy.

Earbuds and headphones, though, don't simply give us access to personalized soundtracks; they also filter out external noises, transforming sound waves from something implicitly communal to something stubbornly personal. As Trevor Pinch, a professor of Science and Technology Studies at Cornell, put it to me: "Sound has become more thing-like—it's become more mediated by technology." We may not have earlids; earbuds, however, get us pretty close.

Music playlists are so intimately calibrated to our desires that glimpsing someone else's screen can seem like a violation of privacy.

The next phase of sonic input may take the logic of earbuds to another level. Earlier this year, Rudolph Stefanich, an industrial designer currently based in Shanghai, announced the creation of Sono, a device that promises to control sound levels within buildings by turning up or down specific noises from the surrounding environment. Sono attaches to a window, Stefanich says, and uses a complex series of sound-wave amplifiers and dampeners to calibrate the waves that end up reaching human ears.

So, ostensibly: You can amplify the songs of birds outside. And you can drown out the noise of the traffic on the street below. You can do to a room's sound environment what David Bowen does to washing machines: calibrate its constituent sounds in a way that will be maximally pleasing and minimally annoying.

Sono is still in its proof-of-concept stage. "At the moment," Stefanich told me, "what I have is a proof that you can reduce noise going through a glass surface by using these pieces." The designer believes, however, that his proof-of-concept can translate quite easily into a consumer good. "It works in a physical way," Stefanich says. "All the stuff that I put together is physically feasible."

What Stefanich is doing in Shanghai—and Acentech is doing in Boston, and Woolworth is doing in New Orleans—may not solve the age-old dilemma of noise control. But their work does what all good data analysis does: It provides a starting point. It gets us beyond unhelpfully simplified discussions of sound to something more nuanced, more contextual, more respectful of the human hearer. "When man regards himself as central in the universe," Murray Schafer noted, "silence can only be considered approximate, never absolute." The same may be said of noise.

ABOUT THE AUTHOR

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