SOUND CONNECTS US

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Connection Today

I find myself thinking more and more about connections. People tell me they have difficulty making and keeping connections. Even before a pandemic turned us inward, physical connections with people were waning. Why meet up with friends when you can keep up with their doings on social media? Why shoot hoops at the corner court when you can curl up with an Xbox and talk trash through your headset? Yet depression and alienation are rising.

In his book *Lost Connections* Johann Hari tells us this increase in depression goes beyond a simple increase in diagnosis [1]. He attributes the rise in depression in part to a decrease in connectedness with others. Medication will help in some cases. But, medication does not treat loneliness. It does not treat the lack of belonging that is increasingly prevalent.

Traditional ways of belonging—such as religion and church membership—provide connection to people who see you and value you, and whom you, in turn, see and value. They position your life and your future as parts of something that makes sense. But, this kind of belonging and connectedness, not just religion but bowling teams or Moose Lodge membership, is disappearing. Children tend to disperse as they age out of living at home. Longstanding intergenerational communities are rare. The concept of the place you grew up being a "hometown" has little meaning when no one you were close to as a child, including your siblings, still lives there. Increasingly prevalent are parasocial relationships—those with people you don't know, such as feeling an affinity for a celebrity or an athlete or a politician. Relationships can become less important than social media contacts, the Twitter accounts we follow, or our Facebook likes.

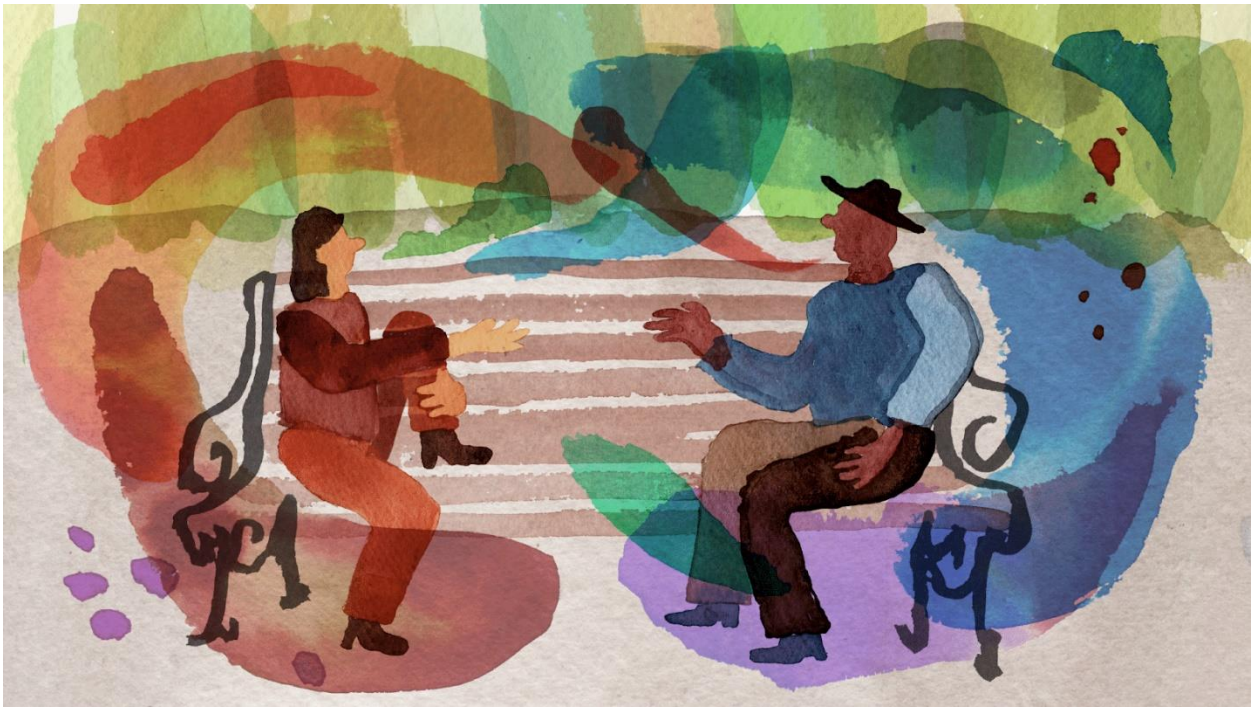
So how do we—how do *I*—make connections in this less-connected moment? Whether in person or by phone, Zoom, or Skype, I find that sound is at the root of how I make and keep connections. In my book *Of Sound Mind*, I define the sound mind as the brain that evolves from our experience with sound throughout our lives. The sound mind is vast—interconnected with neural systems that underlie each of our senses: the motor system, the limbic (emotional) system, and cognitive (memory, attention) systems. I make the case that the sound mind influences and is influenced by how we sense, feel, move, and think. Sound connects us. It is continuous, integrative, and expansive. It shapes who we are and how we connect to the world.

We feel disconnected in part because we have moved away from our sonic roots. Sound is supplanted by vision-centric social forces. Nuanced listening is impeded by a rise in noise. Yet the deep neural interconnectedness embodied in the sound mind gives me hope. Hearing is not an isolated sensory process, a cog in interpreting the sensory world, but is a lead player in every part of us. When the world is falling apart, sound can connect us. Sound holds one key to fostering the sense of community we're looking for.

The Holistic Power of Sound

Sound has been of mighty importance for us for a long time. It has deep biological roots. We've been communicating with sound for hundreds of thousands of years—way before it occurred to anyone to start writing down our thoughts and messages. Throughout the ages religions have relied on sound- imagery like "the word of God" and "the word made flesh" [2]. Ancient bards did not write their tales down. They memorized the important themes and composed tales anew with each telling in the songs they sang. Sound is mnemonic - it helps us remember. When listening one must rely on memory—you cannot go back and replay what you have heard in the same way you can reread the last page of a book. Socrates worried that writing would come to supplant the oral traditions of teaching and learning and would produce a citizenry with poor memory. Historian and philosopher Walter Ong wrote that sound has been eclipsed by vision. Maybe he is right; maybe we have lost our way.

Indeed such a concern about not exercising our memory applies anew in the digital assistant era. Why bother wracking our brains trying to remember an elusive fact, or how to get to an upcoming appointment when we can simply turn to Google?



Sound fills the space surrounding you and me and connects us when we speak. Sound is alive. Sound is a presence. We have no script when we talk. A good conversation has a rhythm and is outside of either person's control to direct. When we're truly listening to one another there is reciprocity, reverberation, and tunedness; psychiatrist and scholar Iain McGilchrist calls it "betweenness." It is probably the most precious form of communication there is. I feel betweenness every time I take my position in the front of a classroom. I try to create a dialogue with my students, to facilitate interactive sessions where deep discussions can take place without adhering too closely to the day's syllabus or the clock on the wall. Since the publication of *Of Sound Mind*, I have been

a guest on many podcasts. I am finding the connections I build in these conversations, with sound as the medium, to be much more real than I expected.

Hearing evolved as a means to keep us fed, to keep us safe from predators, to warn of us of danger, and to connect us with potential mates. Today, hearing is unnecessary for most of those activities. Can being attuned to the power of sound give us a better chance of solving alienation, isolation, depression, anxiousness, and division? My argument is sound can heal and strengthen our humanity if we relearn to value it.

With the ancient Greeks' recognition of sound as a powerful force in the body and mind as inspiration, and the study of biology to guide me, I have dedicated my career to better understanding how sound impacts our lives. And I have seen evidence of sound operating for both good and bad in my own research and that of colleagues from around the world. I have assembled here examples that, for better or worse, illustrate the power of sound.

Disrupting the Sound Mind

Noise

Noise, which can be defined as unwanted sound, is so *so* pervasive. Coming from the same linguistic root as nausea, noise can be literally sickening.

Few people realize there are two types of noise. Everyone knows about the danger of loud sounds. If you spend too much time in a noisy place, using noisy tools, or listening to loud music, your ears may be damaged. NIOSH (the occupational safety watchdog) is very clear that noise above 90 decibels causes hearing loss. There is no mistaking an ear-damaging noise when you hear it. It is LOUD.

The sound of my neighbor's leaf blower on the other hand, at least from the vantage point of my backyard, does not meet or exceed the NIOSH's accepted threshold of "unsafe." It is the sort of sound most would consider background noise. For this reason, we tend to ignore it. But are we really tuning it out, or are we simply adapting our lives to a constant state of low-level alarm? We have all had the experience of noticing a sound only when it goes away. Often it is an air conditioner or an idling truck. The air conditioner cycles off or the ignition is cut, and suddenly we "hear" the silence. And we sigh in relief. We momentarily revel in the peace until it starts up again or is replaced by the next aural annoyance. If our ears are not being damaged and we can mostly tune them out, why should these noises concern us? We should be concerned for the sake of our brains.

Chronic noise exposure— such as might be experienced by individuals who live on a bus- and taxi-filled street or near an airport—can lead to an overall decrease in perceived quality of life, elevated stress hormones, problems with memory and learning, difficulty performing challenging tasks, and stiffening of blood vessels and other cardiovascular diseases [3-7]. According to the World Health Organization noise exposure and its secondary outcomes such as hypertension and reduced cognitive performance account for an astounding number of work years lost due to ill health, disability, or early death [8].

This type of noise exposure is especially devastating for the developing brain. Children's brains are primed to extract meaning from sound and are typically good at doing so. But the ability to take meaning from sound can be compromised by chronic exposure to meaningless sound [9-15]. There is an elementary school in New York City that, on one end, abuts a busy elevated subway track. Reading scores of children in classrooms on the noisy side of the school lagged those of their peers on the quiet side of the building by up to eleven months. Noise mitigation efforts that included rubber rail padding and noise abatement materials in the classrooms erased the learning gap [16,17]. Young animals exposed to moderate noise (typical of commercial white noise machines) fail to develop precise neural differentiation of the constituent parts of common sounds [12,13].

Birds and other animals change their vocalizations in response to human-made noise. Birds, frogs, and whales—like humans—increase the loudness of their voices as the environment gets noisier. Animals change their call rates or pitches, or devise other changes, just to make themselves heard over us [18-21]. Some animals simply give up. Ship sonar can cause whales to go silent. It also interferes with the echolocation they rely on for navigation [22]. Human-created noise has forced hundreds of species of animals around the world to alter their behavior, with dire consequences for mating, migrating, and their continued existence on Earth.

Sound is one of the vectors by which all living organisms are linked in a unified ecology. Even plants emit and sense sounds in the interest of nourishment and pollination. Plants' roots seek out water; that is why regular augering of the main sewer line is often necessary. We now have learned that roots will grow toward the *sound* of water [23]. Certain species of flowering plants will release nectar only when a bee buzzes at a particular pitch, which it uses to ensure that the bee species is a known good pollen spreader [24]. All living things respond to sound and vibration. Humanmade sound exerts its unseen sway well beyond the human community, deep into the community of all living things.

Sound is under-recognized largely because it is invisible. We notice more obvious environmental causes—forests, fossil fuels—while ignoring the impact of noise on animal communication, mating, and indeed survival. Once aware of the noise that surrounds us, we can then ask ourselves, is it necessary? Do we need music playing in the grocery store or while on-hold on the phone? Do we need to let everyone nearby know we are unlocking our car door?

Finnish architect Johann Palaasma wrote, "Every city has its echo which depends on the pattern and scale of its streets and the prevailing architecture styles and materials. The echo of a Renaissance city differs from that of a Baroque city. But our cities have lost their echo altogether. The wide, open spaces of contemporary streets do not return sound, and in the interiors of today's buildings echoes are absorbed and censored. The programmed recorded music of shopping malls and public spaces eliminates the possibility of grasping the acoustic volume of space. Our ears have been blinded [25]." Noise disconnects us from the places we live in.

Have you felt it is becoming more difficult to focus your attention? Sound is our alerting sense. It evolved to keep us safe. Of course, being on perpetual sonic alert will distract us from what we're doing.

Concussion

Making sense of sound is one of the hardest jobs we ask our brain to do. The ingredients of sound—pitch, timing, timbre, loudness—occur simultaneously, and the brain has to make sense of what is said with microsecond precision. A concussive blow to the head can disrupt this delicate processing. With scalp electrodes it is possible to measure how concussion can disorganize the brain's response to sound [26-28]. Assessment of sound processing in the brain can be used to inform concussion diagnosis and treatment.

Germane to music, concussion can disrupt rhythm processing. A few years ago I attended a fundraiser for the Concussion Legacy Foundation, which seeks to reduce the incidence of concussion in sports. After the speakers, the music started, and I found myself on the dance floor surrounded by football players. To a man they were phenomenal dancers, responding much more fluidly to the beat of the music than I would have thought possible of these mountains of men. This experience, along with the power of music to strengthen the brain discussed in the next section, led us to look at rhythm in concussed athletes. Namely, we looked at their ability to clap along to a metronome, a marriage of sound and motion. Sure enough, this ability was disrupted in concussed athletes, a finding that advocates for considering auditory-based rhythm training to speed concussion recovery. A merging of the arts and science, exemplified by organizations like Athletes and the Arts, is likely to go a long way to enhance athlete health through music.

Strengthening the Sound Mind

Making Music

Making music changes us profoundly. I am talking about strengthening our senses, our bodies, our cognition, and our ability to learn.

Making music alters *how our brain processes sound*. Regular music-making creates lasting changes in our vast hearing brain - our sound mind. We see stronger neural processing of the harmonics in sounds and that the timing of processing of certain sound components is faster. Harmonics are what distinguish the sounds of a flute and a tuba playing the same note. Harmonics help us distinguish one consonant from another, such as "d" from "g." Timing cues ranging from microseconds to seconds are everywhere in both speech and music. These brain changes span all types of musicians—instrumentalists and vocalists—and span genres, too.

There is specialization as well. If you are an instrumentalist, your brain is tuned to the sound of your own instrument. If you play the flute, your brain will encode the sound of a flute more richly than will the brain of a non-flautist [29-31]. If you are a music conductor, you will be able to localize sound better in space—in the orchestra!—than a non-conductor musician or a nonmusician [32]. Your own personal way of making music changes the sound mind in ways we have yet to discover.

Playing music influences how we see. People who regularly make music can more quickly perform tests involving detection of subtle movement than those who don't [33]. They also can combine the input from their eyes and ears more efficiently [34].

Playing an instrument affects our motor and somatosensory (touch) systems. We know the left hand is controlled largely by the right side of the brain and vice versa. Playing the violin requires both hands, but the movements of the left hand require more control of individual fingers compared

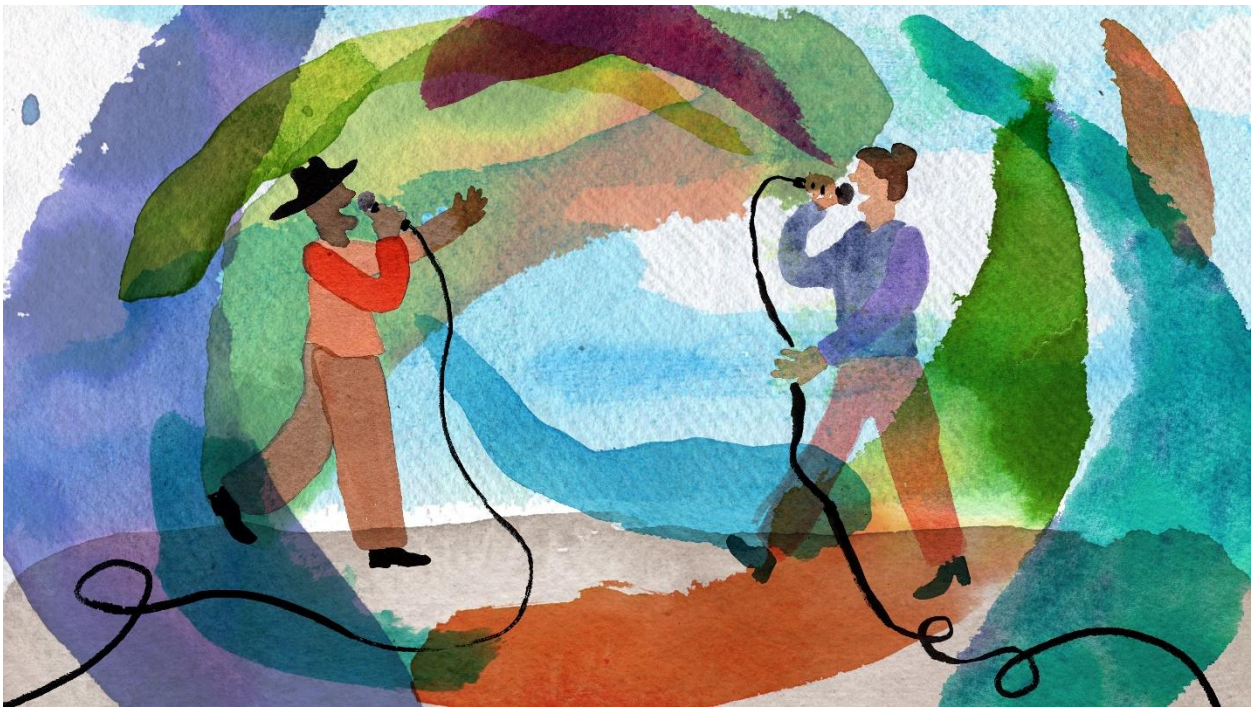
to the nuanced bowing motion of the right hand. In violinists, the right motor cortex—controlling the left fingers—expands and takes over neighboring regions ordinarily devoted to the palm [35].

Music making affects our emotions. Indeed, listening to music activates the reward circuitry of the brain [36]. Musicians can learn to process emotional cues in others' voices better than nonmusicians. Their brains are more attuned, for example, to the emotion-bearing components of a crying baby [37].

Making music exercises attention and memory. Musicians are able to focus attention better while avoiding distractions [38-44]. They outperform nonmusicians in memory tasks, including verbal memory, working memory, and sequencing [45-59]. Gaining an edge in working memory helps you listen. If your working memory is good, you will probably be better at following conversations in noisy places like a crowded bar or restaurant. And indeed, science has found this to be the case. Studies of musicians' ability to listen to speech in noise, for the most part, have found they perform this task better than nonmusicians [51-53, 60-69.]

Musician students tend to do better than their nonmusician peers in reading [70], measures of overall intelligence, and academic achievement [71-73]. Changes in academics and brain function don't happen overnight. I saw this first-hand in the students enrolled in the Harmony Project in Los Angeles. The Harmony Project is a community music education program that brings music instruction to youth from low-income families and under-resourced communities. School-age children enrolled in the Harmony Project showed heightened neural processing of sound compared to their equally motivated but waitlisted peers after only two years of high-quality music instruction [74,75.] We replicated these findings in a similar study conducted in Chicago high-school students. The musicians were compared to students in the same schools engaged in another enriching activity. After two years of in-school music instruction, notable changes were found in the neural processing of crucial sound ingredients - such as harmonics and timing - together with improvements in language metrics such as phonological awareness [65,76] .

How does music make all this possible? The sound mind is vast. Making music engages not just our ears, but our motor and visual systems. Making music depends on focused attention, it involves memory, and it engages our emotions. Perhaps uniquely, music does an exceptional job connecting all these systems.



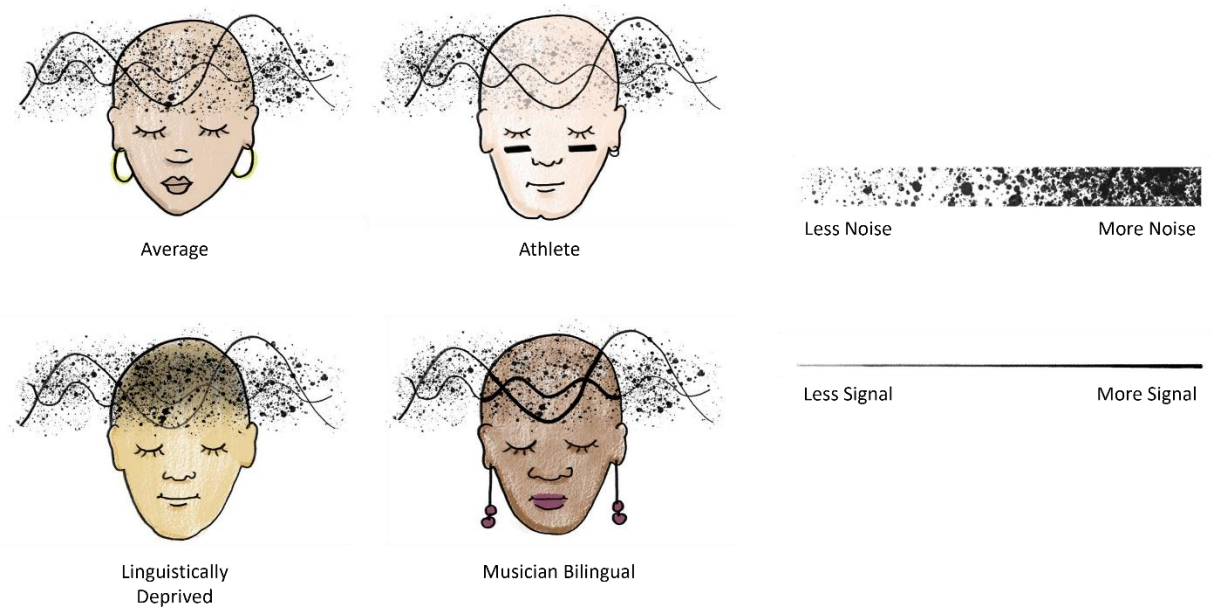
The illustration above depicts the connection that arises when singers join their voices in harmony. The singers' voices and their movements join in a continuous back-and-forth, a give and take that dynamically shapes the flow of a piece of music. Indeed, this give and take, with practice, can become a transcendent aural experience. And, there is "blood harmony"—the sublime, close harmonies that seem to be unique among families, especially siblings. The Everly Brothers, the Louvin Brothers, and the Carter Sisters (along with mom Maybelle) can produce harmonies rarely achievable by non-related singers. A genetic component is likely involved, but I believe that living under the same roof for years tunes one's experience with the voices of one's family members and influences how siblings' voices blend.

Speaking More than One Language

If I could choose a superpower I would like to have the ability to speak any language. A person's language is that person's sense of belonging and of home. Sharing a language means sharing a way to make sense of another person's world. People who speak more than one language naturally use sound to connect with more people. They also use sound to tune their hearing brains. First, bilinguals tend to be masters of pitch. In many cases, bilinguals will speak one language at a higher pitch than the other [77,78.] Stronger neural processing of the fundamental frequency in sound (an important pitch cue) tunes them into the pitch of others' voices, which helps distinguish between similar voices, and to hear "auditory objects," like your brother's voice or the singer in the band. They also, by virtue of having a larger inventory of sounds available to them, have richly tuned sound minds. This shows up in different ways, but the most salient is in the domain of attention and, in particular, inhibitory control. Bilinguals can suppress distractions when accomplishing a task—to get down to business at hand—while ignoring other demands on their attention [79-82]. Their experience suppressing interference in one language when speaking or writing in another hones focus to a sharp point.

Exercising the Body

A group of people you might not immediately think of as sound experts are athletes. There is growing understanding that the sound mind is shaped by athletic activity. Athletics involve listening and responding to teammates' cues and coaches' instructions, and to the sound of activity on the playing field itself. We have discovered that athletes have uncommonly "quiet" brains—ones with a lower level of turbulence in its resting state. When you are resting, perhaps sitting quietly lost in thought or perhaps not really thinking of anything at all, the brain does not rest — it is always *on*. Synapses continue firing randomly here, there, and everywhere in the brain. This neural activity is not in reaction to anything you are seeing or hearing or touching, but it is there nonetheless, including in the sound mind. Think of it as electrical static. When you are at rest, this neural noise ideally is minimal, like a clean desk before you start to work. With this tidy cognitive desk, an athlete can get right to it when some work comes along [83].



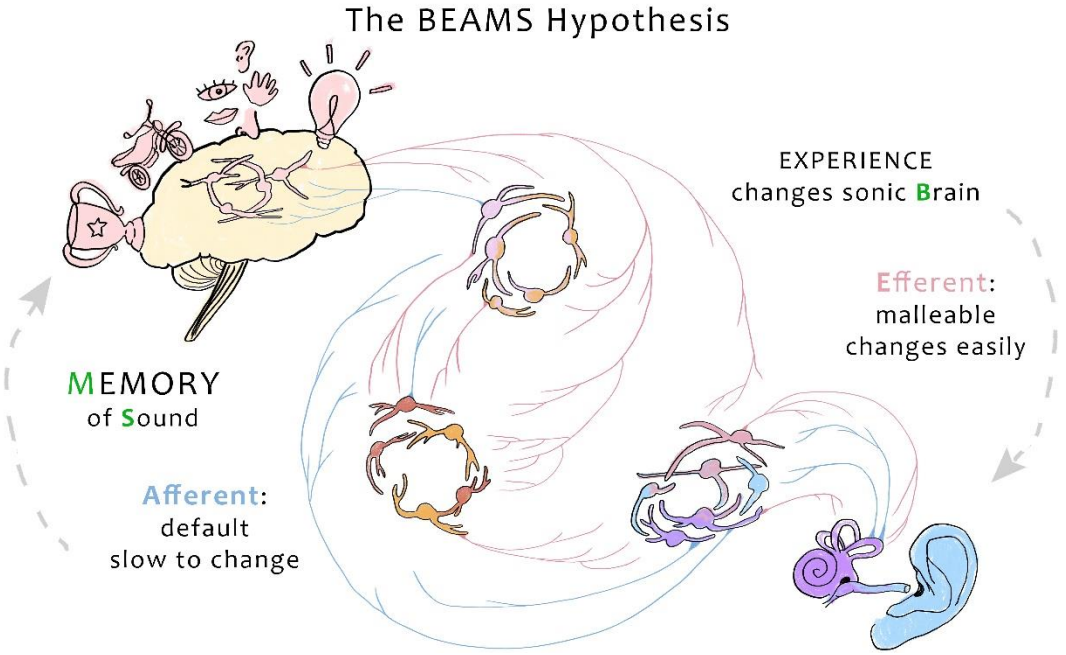
In the figure above, I have depicted a "signal," a desired sound, as a pair of undulating waves. "Noise" is the swirl of foggy dots around the signal which represents the background noise in our own brains. Desired signals must always compete with some degree of noise created inside the head in addition to the noise outside the head, in the environment.

An incoming signal is processed in the brain with various levels of success, depending on the individual. A musician's brain and a bilingual's brain will strengthen the signal. In the image that depicts the musician and bilingual, an enhanced signal stands out starkly against the noise, enabling an ease of signal processing. In contrast, an individual who has been linguistically deprived, perhaps due to growing up in impoverished circumstances, has the noise in the brain turned up, making the signal more difficult to discern. Our athlete, on the other hand, has less noise in competition with the signal. Taken together with an enhanced signal [84], the message gets through loud and clear, landing on a quiet neural runway.

Our Sound Mind Makes Us *Us*

The brain is an organ of prediction. Our behavior—how we react in any circumstance—is based on who we have become, based on what we have learned throughout our lives. We operate from this bedrock using a combination of intuition and logic built up from experience. Based on probabilities and past outcomes our brain is equipped to do what it must do at any given moment.

How do we form this bedrock of who we are? In part from our memories. When we hear a sound, our ear—the cochlea—sends a neural signal to the brain. This ear-to-brain (afferent) pathway is complemented by the pathway going the other direction from the brain to the cochlea (the efferent pathway). Why does the brain need to talk to the ear? A chief role of the efferent pathway is to prepare the ear to gather the right information under the circumstances. It quickly alters the sound mind's response based on the importance of the sound. Over time an important sound—perhaps your mother's voice—earns preference in processing due to careful sculpting of the afferent pathway by efferent signaling. The memory of the sound of your mother's voice now resides in your automatic neural circuitry [85]. Primed to respond optimally to your mother's voice, your brain gives precedence to that sound. You are likely to hear it even if you're asleep. A prediction is made, based on memory, that it is a voice of consequence.



I have summarized auditory learning in the BEAMS hypothesis [85]. The hearing brain interacts with the other senses, the motor, emotion and cognitive systems of the **B**rain. This experience with sound effects changes through the **E**fferent (brain-to-ear) circuitry—which is massive. Over time, as importance is established, the **A**fferent (ear-to-brain) pathways change, representing **M**emories of the **S**ounds of our lives.

Our history with sound then, is crucial to how our brain works. Our neural pathways are sculpted by our lives in sound. This process doesn't happen quickly. You do not gain the advantages described above with a week of musical instruction or a half-semester of Spanish or a month at the gym. But over time it adds up. Memories for sounds are made, neural pathways are altered, and automaticity replaces labor. The signal overtakes the noise. Eventually, with music practice, with

athletic competition, as we get older, the sounds of our past bring about a foundation of sound processing in the present. The sound mind continues to accrue wisdom, building on the foundation of memories that makes us *us*. The sounds of our lives shape our brains.

Biological Connections

I opened this piece with the premise that sound connects us. We connect with our loved ones by speaking with them. We connect with the sounds of home. These sound connections have a biological basis. Music engages broadly similar cognitive, motor, and limbic activity in all of us [86,87]. Our brains operate in sync with our fellow concertgoers in an orchestra hall or a concert venue. Not only do we nod our heads or tap our feet in synchrony, but we are connected in our brain rhythms. The friendly feelings of bonding at a concert come in part from the biological synchrony engendered by the rhythm in music [88].

We are *built* to connect with sound. Consider the voice. A group of researchers studied the sound components of the spoken word by analyzing speech samples of over 7,000 speakers from around the world. The sample included speakers of English, Farsi, French, German, Hindi, Japanese, Korean, Mandarin Chinese, Spanish, Tamil, and Vietnamese. They found that whether male or female, young or old, and irrespective of language, human speech shares certain consistent, universal, vocal resonances. In other words, all of us have the raw materials—the esophagus, the larynx, the oral and nasal cavities, and their accompanying resonant properties—to connect with sound. We all own the same instrument.

And what's more, the sounds we make with these instruments are musical. When we speak, we produce a fundamental frequency (what we perceive as voice pitch—generally higher for women, lower for men) and harmonics of the fundamental frequency. We shape the relative sizes of these harmonics with our tongues and the shape of our mouths; this is how we form the sounds of speech [89]. The resonances in our speech occur at ratios aligning with the most consonant musical intervals like the octave (2:1), the perfect fifth (3:2), and the perfect fourth (4:3). This musicality in speech spans speakers of all languages. Human music naturally echoes the human voice.

Our group wondered whether vocal resonances might be affected by musicianship. We applied the same analysis that revealed musicality in speech to the speech and song of musicians and nonmusicians. While all the participants had the same prominent vocal resonances, defined by distinct peaks at consonant intervals such as octaves, fourths, and fifths, the musicians had *less acoustic noise in the troughs between the resonant peaks*. Instrumentalists had less noise than non-musicians. Singers' voices had the least noise of all. This was true whether the participants were singing or speaking [90]. Thus there are both individualities and commonalities contributing to the sounds we make and connect with.

Observing the alignment of brains in Egyptian fruit bats has revealed some biological underpinnings of how these connection are made. Collectives of bats, which form long-lasting social bonds with members of their group, synchronize their neural activity in the frontal areas in their brains when one of them emits a call [91]. Interestingly, bats that are socially closer to the caller have stronger brain coupling than members of the group that are more socially distant in their relationship to the caller. We are biologically wired to connect to one another using sound.

Science is an Art

As an undergraduate comparative literature major, I never would have found my love of biology if I hadn't been forced to take it as a distribution requirement. Education has become specialized at the expense of a broader view. Art and science used to be more tightly coupled. Today science is estranged from the humanities, and it is becoming less human as a result. In the public eye science is often seen as the domain of tangible facts and hard-won truths while the humanities, including art and music, are where imagination comes first and the intangible reigns. But both science and art have tangible and intangible properties.

There is something marvelous about music that defies the type of quantification the scientific process requires. Every scientific perspective must acknowledge both what it can measure and what it cannot. Einstein wrote "there comes a point where the mind takes a leap—call it intuition or what you will—and comes out upon a higher plane of knowledge, but can never prove how it got there. All great discoveries have involved such a leap [92]." He also said, "At times I feel certain I am right while not knowing the reason" and "Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution. It is, strictly speaking, a real factor in scientific research [93]." (Incidentally, Einstein claimed to think in music [94].) Good scientists use imagination and embrace the intangibles—what we cannot measure—that are part of the system we are investigating.

Metrics such as reading scores and brain scans go a long way toward making the argument that music training should be provided in schools. However, learning to play music provides many intangible benefits that are hard to measure. What about the focus and discipline that years of practice engender, the satisfaction of being a part of a musical group, the confidence hard won from performing on a stage? These intangibles count as benefits even though they are difficult to quantify on an MRI or on a standardized test [95].

Policies, laws, and regulations are often made based on (the tangible)—what we can measure—and are often in response to complex incentives. Sometimes this focus on the tangible comes at the expense of a more holistic appraisal of its impact on our relationships and our communities.

Consider how the logic of what we can measure makes itself heard in the beeping trucks we all listen to every day. It is much easier to measure deaths from accidents involving reversing trucks—a measurable outcome—than damage to the sound mind or to the hearing of people who drive trucks or live or work around them. So, OSHA regulations require that nearly all commercial trucks must beep when reversing.

There are also marginal decreases in the responsibility of truck drivers and pedestrians, which erode whatever notions we may have of our roles in caring for ourselves and the people around us. It moves employers closer to hiring a zero-liability employee, and an employee who can do no harm surely can be less skilled, and maybe paid a little less—a measurable outcome.

But meanwhile, we tune the beeps out. We all become that much more likely to put on our headphones, close our windows, turn on white noise, or just stop listening altogether. Worse, some listeners no longer notice. If we are tuning that out, what else is passing us by? How much connection, peace, and agency have been lost in the process?

In the contemporary world, those of us who care about our sound minds have no basis for arguing against the beeping. What matters is how many or how few truck accidents have been prevented. *Just because it cannot be measured does not mean it's not important!*

In an example of misplaced metrics, some years ago, in an attempt to manage public spending, the Arts Council of England imposed objective "quality metrics" on art to determine whom to fund [96]. The worthiness of a piece of art or an artist was determined by a series of checkboxes on a form. If Stravinsky or Warhol or Gaudí had to rely on a clipboard-wielding functionary to proceed with their art, can you imagine how much more the impoverished the world would be? I have a difficult time believing an Arts Council metric that would adequately anticipate *The Rite of Spring*, soup can silkscreens, or Casa Milà. What makes art *art* is often unmeasurable and also unforeseeable in advance.

One of the biggest challenges facing music research is you can rarely get two people to agree on a definition of what music is. The temptation is to limit variables, either by restricting your definition of "musician" or by creating in-lab instruction. Neither option is particularly good. If we find out that classically trained French horn players with between thirteen and fifteen years of experience can solve crossword puzzles 30% faster than nonmusicians, does this really tell us anything about *musicians* generally? If we create a music training regimen that involves undergraduate non-musicians coming to the lab to follow a 30-minute music training course three days a week for four weeks, have we really learned anything about the brain of a musician "in the wild"? Science demands tight control when it comes to clinical trials. If you are testing a drug to treat a disease, there are rigorous protocols about dosage, controls, strictly defined primary and secondary outcomes and endpoints. Studying music systematically defies nearly all of those requirements. Paradoxically, every layer of control added to music experiments can obscure the intangibles that make music what it is. Balancing competing priorities is hard—requiring nuanced thinking and decision-making.

This does not mean we should not research music. On the contrary. Happily, initiatives to study music in the context of medicine and healing are beginning to cross disciplinary boundaries and embrace leaps of intuition. The Sound-Health initiative—a collaboration between the National Institutes of Health, the John F. Kennedy Center for the Performing Arts, and the National Endowment for the Arts—is working to expand our understanding of how music impacts the brain and how this knowledge can be harnessed for health and wellness. When NIH director Francis Collins called upon his 27 Institutes to gauge their interest, 22 indicated they could envision a place for music in their institute portfolios.

Renée Fleming embodies the very borderless mindset I embrace. This is evident in her musical expression—opera, musicals, lieder, jazz vocals, Christmas carols, indie rock, and improvised singalongs with family and heads of state. Fleming is an inspiring ambassador for the arts. But also, as a key member of this initiative, she has shown a deep understanding of what can be gained by marrying art, science, and policy—as they were during the Renaissance—and looking toward to a broader, more flexible view of what can be. Because of the nature of the arts, this initiative will enable us to value what can't be measured as well as what can.

For example, one way of striking a balance between measurement and the intangible dimensions of music is to set up a science lab in the space where art is being produced. We chose to work in the context of existing, successful music programs in Los Angeles and in Chicago, not fabricated conditions. At the same time, our chief biological metrics were objective, unambiguous electric signals.

Having taken part in the Sound Health initiative since its inception, I am hopeful the study of music in medicine and education will clarify how music and biological health coincide. Science and the arts are reinforced by embracing and guiding each other. We discover new truths by making connections with seemingly disparate ideas. It is an *asset* that music doesn't lend itself easily to the clinical trial blueprint appropriate for drug studies. This requires scientists to evaluate converging evidence and reach decisions using a combination of intuition and experience instead of searching for *the* answer or *the* proof in a single conclusive study. We can think in new ways to maintain scientific rigor while still allowing music to be *music*. By its very nature sound, and thus music, flows; it cannot be captured. Yet considering what we can measure and what defies measurement *simultaneously*, we can honor the depth, the nuance, and the context embodied in music and in science.

That's Some Brain!

Remember the story of *Charlotte's Web*? A family wakes up one morning to see "Some Pig" woven in the spider web above their piglet, Wilbur. Word gets around, and soon everyone is convinced that Wilbur is a special pig indeed. He is treated with respect and ultimately saved from slaughter thanks to his friend Charlotte's silken message. Only one person—the mom—actually articulates that Wilbur, although remarkable in his own way, isn't the only special one here. She says, "That's some spider!"

This story came to mind while listening to a discussion of the wonders of cochlear implants. These are amazing devices that convert sounds into electrical impulses stimulating the auditory nerve directly, bypassing a non-functioning ear. With them, the deaf are able to hear—a triumph of biomedicine.

Indeed, the technology behind cochlear implants is remarkable; however, it's the *sound mind* that makes them possible. Cochlear implants—from the portable device that uses real-time audio processing to turn acoustic signals into twenty-some streams of electrical pulses, to the skilled surgeons who accomplish delicate precision surgery to place these pulse-delivering electrodes—are truly a testament to human ingenuity. But the cochlear implant would not work without the adaptability, complexity, and interoperability of the sound mind making sense of this unfamiliar input. What a cochlear implant sends to the brain is wildly different from what an ear sends to it. I found myself thinking, *That's some brain!*

The sound mind thrives on connections within the brain, to how we think, move, feel and combine our senses. And it excels in helping us forge connections to others, which can be strengthened by honoring silence, and by engaging in activities such as playing music, speaking another language, and athletics. Tune the sound mind by exercising it!

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