Take Two Notes and Call Me in the Morning
The Science of Music Therapy

by

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ABSTRACT

At the Sherrill House Rehabilitation and Retirement Center in Boston, MA, music therapist Dianne Tow and her interns use a variety of therapeutic interventions to treat physical and psychological dysfunctions–though not every method has been supported by rigorous scientific research. With current technology in the fields of neuroscience and psychology, the effectiveness of most therapies is difficult to quantify. Most of the progress has been made for methodologies targeting physical limitations.

The two therapies with the strongest documentation are rhythmic-auditory stimulation (RAS) gait training and melodic intonation therapy (MIT). RAS gait training is typically used to treat patients with Parkinson's disease or some kind of mobility loss caused by brain damage. Parkinson's disease attacks a person's motor system, and RAS gait training re-stimulates the motor system with music, specifically sound with rhythmic qualities. MIT is used to treat certain kinds of speech loss caused by brain damage in the left hemisphere. Speech is housed in specific organs, primarily in the left hemisphere, but music processing is dispersed throughout both halves of the brain. If the main language enter is compromised, the music neural network can be reworked through multiple therapeutic sessions to help relatively unused language centers in the right hemisphere to develop and grow the connections necessary to produce speech again.

Other music therapies that target emotional and psychological dysfunctions appear to have positive effects, as observed by family members and therapists, but science is not yet satisfied. Human musicality and music's direct effects on our health remain mysterious, but the complexities that have been unraveled thus far with gait training and melodic intonation hold a positive note of hope for the future.

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Take Two Notes and Call Me in the Morning

The Science of Music Therapy

The sun began setting around 4:30 p.m. on a cold day in February. At this time, roughly one third of people with dementia or moderate Alzheimer's disease experience sundowning—a period of time where their agitation and confusion about where they are and what they are doing will peak.

On the second floor of the Sherrill House Rehabilitation and Retirement Center in the Jamaica Plains neighborhood of Boston, thirty sundowning residents were seated in a loose ring following the perimeter of a well-lit room. A few were lying down in mobile hospital beds with heart-rate monitors hooked up and beeping quietly behind them. Some were seated in large leather wheelchairs. The majority seemed to be quite comfortable managing the straight-backed armless chairs that clearly accompanied the five square tables used for small meals and other activities. Aside from the attending nurses, not a single person had a strand of color left on her head.

The room was wallpapered in cream and forest green, and the late afternoon sunlight lent a warm glow to gold trims and accents. Despite the lazy catnap setting, the atmosphere was anxious. A low mumble filled the air, from residents addressing ghosts or the tops of their own feet. Some residents, mentally conditioned for decades to leave work or attend to afterschool activities, were clearly restless—their eyes darted back and forth, their hands tapped the glass tabletops, they rocked back and forth and to and fro. Two stood up to walk. The nurses called the standing residents by name ("Catherine! Where are you going?" "Arthur, come sit back down.") and tried to get them settled in. After all, the music was coming.

And here they came—two young women with guitars slung over their shoulders. Their names were Lauren and Shir, both students in music therapy at the Berklee College of Music and interns under Dianne Tow, the only full-time music therapist at Sherrill House. They strolled into the atrium with big smiles on their faces.

"It's so nice to see you!" Lauren said with a huge grin. She had expanders in her earlobes, a small stud under her bottom lip, and hair dyed black. It was difficult to doubt her enthusiasm when she said, "I've missed you all."

The first song was "My Bonnie Lies Over the Ocean." As a mumbled, almost unconsciously uttered chorus joined Lauren's strong clear voice, Shir walked around passing out plastic eggs filled with beads, a simple rhythm instrument that the residents could bounce to keep the beat. A gentle murmur of "Mmhmm, mmhmm" and grunts of approval punctuated the end of the song.

Their set was composed of songs like "Que Sara Sara," Elvis Presley's "All Shook Up" and "Hound Dog," "That's Amore," and Motown classics "My Girl" and "My Guy."

The musicians switched the role of lead singer every two songs, never halting the stream of music except to ask the residents questions and coax out some participation. As the musicians strummed their guitars and sang, they walked around and made eye contact with each and every resident all around the room.

During the 45 minutes that the girls played, many residents were captivated with the music (or dead asleep with mouths wide open), keeping beat with the shakers and vocalizing the melody or words to the song. But resident Catherine was restless. She stood up multiple times, making a break for the door because she had to go, she had to leave, she had to pick the kids up from school. Shir and the nurse got her to sit back down, but it wasn't until Lauren began singing Smokey Robinson's "Tracks of My Tears" that Catherine went still.

It began with the ear.

At the first chord Lauren struck on her guitar, the outer cup of Catherine's ear funneled sound waves to the eardrum. The eardrum absorbed Lauren's husky mezzo-soprano voice, transmitting hard copies of those airborne vibrations to three small bones: the hammer, anvil, and stirrup. This power triad passed the vibrations along to the fluid-filled, snail-shaped chamber called the cochlea. Inside the cochlea, the basilar membrane separated Lauren's voice from Shir's whenever they harmonized. Their separated voices triggered different sets of tiny, microscopic hair cells. As they vibrated, the hair cells signaled the release of glutamate, the first chemical messenger in this long mechanical game of hot potato. Glutamate tickled sensory neurons in the auditory nerve. The longer particular neurons were stimulated, the longer Lauren and Shir seemed to be holding onto the last word "face."

The auditory nerve channeled an electrical interpretation of the song into Catherine's brain stem, where some sound triggered motor neurons and the rest registered in the temporal lobes located above each ear. Only at this moment was Catherine aware that she was listening to a song. The primary auditory cortex fine-tuned spatial and complex tone information already labeled by the auditory nerve and brainstem. Different musical elements—pitch, volume, timbre, rhythm—dispersed throughout the brain. Pitch, what distinguishes a "high" note from a "low" note, traveled to the right temporal neocortex, the right secondary auditory cortex, and posterior secondary cortex. Rhythm and meter got divided up between the cerebellum and basal ganglia.

The right auditory cortex kept track of the song's sequence, which allowed Catherine to build expectations about how the song would progress. Just as she had become accustomed to common story plotlines over the years, she had subconsciously learned to predict what would happen in an auditory soap opera. A set of dissonant sounds would build tension the way a romantic rival would in a typical chick flick. That tension could be released by a consonant sequence, the happily-ever-after ending that most of us both expect and enjoy. But the ending could also be delayed, and how masterfully her expectations were delayed and thwarted defined the drama that kept Catherine tuned in.

As anticipation built, blood flow increased in small areas loosely arranged in the middle of Catherine's frontal lobes—notably one called the nucleus accumbens, which filled with increasing amounts of the neurotransmitter dopamine. The simple act of listening became a pleasing activity, creating a smile that tugged ever so subtly at her lips.

Then—the chorus, a climax, a spike of dopamine levels. All the tension built up by individual notes resolved in a satisfying, consonant chord. Electrical activity in Catherine's left frontal lobe intensified as a flood of positive emotions washed over her.

For Catherine, perhaps Smokey Robinson's repertoire was rooted deep in her past. The words, melody, and tempo would, of course, pick at neurons and heartstrings. Maybe the music transported her. No longer was she in a room surrounded by strangers, uncertain of what she was doing there or why. Maybe, at that moment, she existed somewhere in her past, laughing with her husband, all of her memories intact—happy.

Lauren and Shir ended their set with "Somewhere Over the Rainbow," which the residents accompanied with a strong, girlish warble. Sundowning was past. The hum of friendly small talk replaced the strange, tense sense of suppressed urgency. The musicians bowed, thanked their audience for being so wonderful, and bade them farewell.

Downstairs from the Alzheimer's floor, the interns shared a solarium in the Grande Room, a comfortable space furnished with cushy couches, guitars, djembes, and keyboards. A large cabinet contained tambourines, shakers, small hand drums called doumbeks, and a large tote bag of rainmakers. Album covers for Frank Sinatra, Edith Piaf, and the Beatles graced the walls. A willowy blonde with her hair pulled back in tidy French braids, Dianne Tow was enthroned at the room's only computer, sipping from a cup of water as she listened and offered feedback to her excited interns.

It had been a good session, they told her. So many of the residents had participated, and they really, really enjoyed the admittedly improvised set. There had only been one or two incidents, and none too serious. Overall, they felt accomplished–music therapy, it seemed, was a good fit for them both.

Their mentor was encouraging. Tow had wanted to be in music from a very young age. Performing and teaching didn't seem like her cup of tea, so when her mother brought home a pamphlet on music therapy, she became intrigued. She double majored in music therapy and education (just in case, she admitted, that therapy wasn't the right path) but found that she loved working with the elderly–starting with the day one of her group participants reared up and punched her square in the gut.

"I slowly stood up and I looked at her, and her face softened. She said, 'Oh, aren't you pretty.'" Tow laughed at the recollection. "Right there, I was just hooked. Anyone who can hate me one second and then ten seconds later just think I'm the cat's meow...oh my gosh, I love this. You just never know what to expect."

After graduating, Tow made a pit stop in Kansas before deciding that she wanted a city experience in New England. Sherrill House had been looking for a full-time music therapist at the time, and Tow fit the bill–and would, for sixteen years.

Besides the sundowning group, Tow and her interns run nine different therapy sessions. Among them is a music and motion group that increased strength and endurance for advanced dementia patients who need auditory stimulation to get exercising; a therapeutic instrumental music-playing group aimed at improving the range of motion, muscle control, and dexterity via the natural physical demands of playing an instrument; and rhythmic auditory stimulation (RAS) gait training to improve walking patterns, typically for patients with Parkinson's disease. These physical rehabilitation techniques fit in a category called neurologic music therapy (NMT), which uses music as a way to stimulate the nervous system without surgery.

In order to maintain her credentials for these techniques, Tow routinely attends workshops and conferences sponsored by music therapy institutions in New York, Colorado, California, Maryland, and Texas. The main NMT certification program was developed at the Colorado State University by neuroscientist Michael Thaut. Thaut, Tow said, is one of the main authoritative figures on evidence-based music therapy.

Unfortunately for music therapists, however, Thaut thinks that most forms of music therapy are backed by "no science at all." The NMT techniques that he helped develop are something separate from the methodologies developed primarily by therapists like Tow since they rely on observations of highly variable patient cases. Science can contribute to therapies by promoting techniques developed from research—but then investigating the efficacy of other established techniques falls to the therapists. Neuroscientists like Thaut, after all, aren't actively looking for therapeutic applications when they conduct research. Rather, they're interested in unraveling the basic mysteries of the human brain.

What scientists knew of the brain's physical structure before the MRI and CAT machines of the 1960s is surprising. For centuries, we have been able to crack open the skulls of cadavers and tease out nerve endings—so we already had a fairly detailed schematic of what brain areas could probably moderate finger movements, or interpret images from the eyes, or send words to the vocal cords. But knowing the nerve connections did not mean we thoroughly understood the content of each neural message being passed along, or even how that information is processed once it reaches its destination. This lingering mystery is like the average grandma opening a modern computer and seeing that the thick red cord connects the hard drive to the motherboard—she can see the parts and how they connect, but she still wouldn't be able to explain how the words she types pop up on the screen.

Armed with newer and cooler tools each passing decade, neuroscientists continue to study how our brains parse a sour note out of a string of tones, how melodies and language are intertwined, and how a beat works its way into our muscles. Current brain-imaging techniques provide details about the brain's physiology by letting us track neural activity through the movements of fluids and electrical stimuli in live subjects. MRIs, for example, provide high-resolution pictures that can go fairly deep into the brain—but at the cost of real-time monitoring. EEGs produce real-time pictures but only at a fairly superficial level, saying nothing about deeper organelles or individual neuronal activity. Combining information from both, though, gives us clues about any number of questions we have about the brain.

And one of the biggest, fuzziest questions on the docket is: why does music affect us so deeply? We humans have long known that we are influenced by music. It pervades our daily existence, sometimes as an intrusion or an escape, modulating our moods and bodies often without our knowing. The more we learn about how much music, the more baffling its power. How did we get to be influenced by something so intangible as a whispered lullaby? How does music alter our physical behavior and abilities?

And who do we rely on to answer these questions? The neuroscientists who are dissecting brain functions in a lab? Or the therapists who witness music's behavior-changing effects first-hand?

The Voice of Science

It was Valentine's Day. Lauren and Shir planned their next session in the background, strumming and harmonizing, while Tow prepared for her own therapy group: a song writing session with long-term residents on the third floor.

Sherrill House is a non-profit, funded mainly by Boston's Episcopalian Trinity Church in Copley Square. The House has four residential floors, one specifically for dementia care and one populated by short-term residents recovering from knee or back injuries. The other two floors are traditional long-term units with a mix of diagnoses, though most are cognitively intact with only mild memory problems. Some do have full-blown Alzheimer's symptoms, but are generally well-behaved, in Tow's assessment. Importantly, many are capable of thinking abstractly and using music to express themselves and build social connections with each other.

When a resident is admitted to Sherrill House, Tow conducts a preliminary inventory to assess that person's status and needs. Does she have Alzheimer's disease? Has she had a stroke? Does he need to maintain a particular range of motion? Is he recovering movement from a fall or getting gait back into order? Or does he have something that's affecting his short-term memory?

Unsurprisingly, a lot of residents get diagnosed with depression, and since many are well advanced in age, they also begin "to question what comes beyond," as Tow put it. Music can play a large role in a person's faith and spiritual connection, and making music with another person provides a much-needed social context for people who just need to get out and interact with others in a familiar and non-threatening circumstance.

"Music is something that can focus them on something that they enjoy and can also assure them that they're not alone, that there're people around," Tow explained. "And pretty soon they're distracted away from that, redirected to something that has a purpose, which is getting them through that high anxiety, high agitation time, and when the music is over, it's time to transition to dinner—which," she laughed, "Is another favorite thing."

After the initial assessment, Tow can decide which therapy groups would address that resident's needs and particular interests.

"What I'm here to do is to use my music to facilitate or meet nonmusical goals that I have with people, whether those goals be physical, cognitive, emotional, social, or spiritual," Tow explained.

Of these five health domains, emotional, social, and spiritual changes are difficult to quantify directly and reliably. But physical and cognitive improvements have become easier to monitor and measure, and so the techniques that Tow uses for these problems have a longer paper trail in scientific literature.

The techniques that target physical dysfunctions use sound to stimulate the nervous system, with conscious participation by the patient or not. Yes, exercising to music is one way to keep stretching and maintain muscle strength and dexterity, but the music itself can take part in timing your movements. The auditory nerve connects almost directly to motor neurons in the spinal cord, meaning that sound can bypass conscious registration—an extra step that runs through areas of the brain likely to be damaged in people who have had strokes, Parkinson's disease, or some kind of brain trauma—and create movement. This is the reason a catchy active beat can inspire movement subconsciously.

Michael Thaut's research from the early 1990s found that patients with Parkinson's disease, a degenerative disorder that strikes the central nervous system, could regain a normal walking pattern while listening to music with a strong beat. The governing idea behind this gait training therapy is that, once cued by the rhythm, patients subconsciously know how much time has elapsed and how much time is left, so that they can anticipate, pre-plan, and time their movements to the beat.

"It's like an auditory GPS system," Thaut explained, in a pleasant German accent over the phone. "If you're lost in space, you look at your map on the GPS. Here, if you're lost in time, you get that GPS signal from the outside."

For Parkinson's patients to regain some finer control over arm and leg movements was the goal. The preliminary results, said Thaut, exceeded expectations. With timing explicitly structured or re-structured by the external beat, patients would stop shuffling altogether and walk normally.

How is this seeming miracle accomplished physiologically? Ed Large's Music Dynamics Laboratory at Florida Atlantic University has been looking into this question, and the answer they came up fits much better under physics than biology.

As information and orders are bandied back and forth, neural activity generates oscillations in the electrical landscape of the brain. The distribution of oscillations varies throughout so that slow delta waves may rule one brain organelle while faster beta oscillations dominate another. Coexisting oscillations follow a hierarchy where those with the slowest frequencies (labeled delta and theta) lord over faster ones.

Nestled in the center of your brain is a tight cluster of neurons called the basal ganglia. Research evidence has implicated the basal ganglia in creating a waiting queue out of voluntary motor functions–meaning that they let you decide to scratch your nose before picking it (or vise versa, depending). They also emit fast beta oscillations. Patients with Parkinson's disease tend to have excess beta oscillations all throughout their brain, theoretically caused by malfunctioning basal ganglia.

In 2009, cognitive neuroscientist Jessica Grahn, now at Western University in Ontario, proposed that the basal ganglia help us detect a beat in musical rhythm. Her claim was slow to gain support until recently. As research into the basal ganglia's function continued, a possible connection between Grahn's claim and a potential Parkinson's disease treatment formed. Now, a common surgical treatment for Parkinson's is to implant a brain pacemaker that emits frequencies to disrupt and inhibit excess beta oscillations. The implant is not considered a cure for the disease a whole, but it does seem to help with the tremors that affect motor functions, improving the quality of life for many patients.

Coincidentally or not, musical rhythms and speech are processed as slow frequencies. When the basal ganglia detect an external musical beat, the beat's slow delta and theta frequencies suppress the faster beta oscillations in and around the basal ganglia, essentially achieving the same effect as the brain pacemaker without invasive surgery.

"It's not any evidence," Large warned. "But...if the brain is all about oscillation, and if music is all about oscillations, then it's not surprising that certain kinds of musical stimuli will have some therapeutic effects for people with brain dysfunction. And if we could discover what those general principles are, then we might be able to distill certain kinds of sound patterns that could treat different kinds of ailments."

Perhaps it sounds too sci-fi for a doctor to prescribe sounds and frequencies to treat a disorder—but the idea does have precedence. Tinnitus is a condition where people will hear a ringing even though there's no external source, and the ringing is often thought to herald the advent of permanent hearing loss. One treatment option calls for the patient to listen to edited sounds that have the frequency of their perceived ringing filtered out, for upwards of 12 hours a week. Though scientists are not entirely sure why this particular therapy has gotten such a positive response, the popular theory is that prolonged exposure to this filtered sound resets the patient's tonal landscape. This lets the neurons that keep ringing find their natural rhythm again. Another possibility is that the other neurons begin matching the misfiring ones so that the ringing is canceled out.

But either way, treating tinnitus with specific sound clips has the same problem as gait training: it works—for a while. Few therapies "cure" a disability, in the sense that if a patient does not continue therapy, the effects are not permanent. So the ultimate goal for these temporary effective therapies is to find permanency—by retraining the brain itself.

While completing her neurologic therapy training, Dianne Tow conducted an experiment of her own at Sherrill House to see gait training's efficacy first-hand. Most of gait training's success stories had been reported in stroke patients after six months, and she wanted to see if it would be equally effective for stroke patients two years after their traumatic event.

"That was the busiest four months of my life," Tow recalled. "I found kind of what I expected to find, where...their distance improved, their stride length improved. They were able to even out gait, and their depression scores also went down. But within two months after treatment had stopped, they went back to where their original baseline was."

As dramatic as the results of gait training looks during the first **few** sessions of therapy, the long-term problem remains unsolved. For patients who suffer stroke or brain trauma, the damage does not and usually cannot get reversed. Nothing can really repair the parts of the brain that have been physically compromised, but the processes they were once responsible for can be redistributed. The damaged areas can be bypassed. The real rehabilitation goal is not to succeed at walking normally during therapy sessions, but to retrain the brain so it can handle walking without music even after sessions decrease or stop.

Before the 1970s, the prevailing belief was that the disposition and brain you were born with was all you got. There could maybe be some development during those awkward years of puberty. But the idea that adults could also change their brains was only broached in recent decades. The argument began in 1923 with Karl Lashley's studies on rhesus monkeys, but it wasn't until the 1960s that experimental evidence showed that the brain could build new neural pathways or repurpose defunct structures.

One of the pioneers for the case of brain plasticity, Paul Bach-y-Rita at the University of Wisconsin, provided evidence by providing sight to the blind. "We don't see with our eyes. We see with our brains," he said–meaning that, as long as outside signals gets to the part of the brain that processes sight, some kind of vision should be produced. He went on to invent a device called BrainPort that fed tactile sensations to the super-sensitive tongue, theorizing that touch receptors could substitute for retinas and that the brain would adapt defunct visual pathways to use taste information to build pictures. When

BrainPort worked, the idea that the adult brain could learn to repurpose sensory details gained impressive (if not immediately accepted) verification.

There are two ways neuroplasticity can occur. First, there's structural plasticity, in which physical parts of the brain actually get bigger or extra neurons and tracts are made between organelles as a result of training. For example, Gottfried Schlaug's Music and Neuroimaging Lab at Harvard University found that children who practiced an instrument for 15 months would develop larger motor brain areas (as playing instruments increases finger dexterity) and an enlarged corpus callosum (also related to improved hand motor function). These changes are like building muscles after lifting weights—and just like muscles, if something goes awry with the regular suspects and routines, then you have to compensate.

That's where functional plasticity comes in. Say that you usually drive to work using one road. One day, without any warning, that road gets demolished. To get to your destination, you start using back roads that you've always known about, but until now they simply weren't the best routes. The same can happen with brain function. The pathways and organelles that process music compose a network of back roads and pit stops that your brain can repurpose to reach the same goal as before.

"The gold standard in [neurologic] rehab is to stimulate brain plasticity that hopefully translates to behavioral change," Thaut explained. "And in the continuum after that, to find ways for patients to continue to train, to work, and exercise."

One of the Harvard Music and Neuroimaging Lab's research accomplishments on neuroplasticity as a function of musical training has shown that musicians have different brains from non-musicians, though the structural brain differences are credited not to music itself, but the physical training process: playing an instrument every day basically has the same neurologic effect as practicing a perfect baseball pitch. However, understanding music involves more than just the physical act of drawing a violin bow across the strings.

"Music is not just listening to pitches and rhythms," explained neuroscientist Psyche Loui (yes, that's her real name) at the Harvard lab. "There's a lot to do with your working memory span and your attention span, and your ability to sit still and practice for that many days has got to transfer to other things."

Actively learning music involves various cognitive processes that can also stand alone—like language and mathematics. When the main centers for those cognitive functions get compromised through either stroke or trauma, musical pathways can help rehabilitate lost abilities. Today, the best example of music and functional neuroplasticity working together successfully is the use of melodic intonation therapy for speech rehabilitation.

Originally developed without this precise neurologic knowledge, melodic intonation therapy began in 1973 at the Boston VA Hospital, not far from Sherrill House, by neurologists Martin Albert, Robert Sparks, and Nancy Helm-Estabrooks. In melodic intonation, the ability to use language moves headquarters, rerouting old functions through back roads and country paths to make use of previously peripheral language organs.

The similarities between music and speech cadences make it easy **for** people to believe that the brain processes the two in exactly the same fashion. But where speech conveys messages with specific meanings, music transmits general feelings. So where the spoken sentence, "I am sad because you ate my cookie" conveys a very specific sentiment, the slow sweeping crescendo of a symphony of violins denotes a general sadness that listeners are free to interpret.

Language's nuanced specificity coincides with how much the brain localizes speech processing. Speech appears to be primarily housed in very specific parts of the cerebral cortex in the right hemisphere of the brain, so that a stroke can wipe out important strongholds of language in a single attack. But processing music is distributed amongst various areas of the brain. Music's dispersed neurological network, which contains smaller, less used language centers in the left side of the brain, preserves knowledge that otherwise would be lost for good.

In 2011, Arizona Democratic Representative Gabrielle "Gabby" Giffords sustained a gunshot wound to the left side of her head, damaging the dominant language center. Because the smaller language centers in the right hemisphere were untouched, though, some speech was retained–just inaccessible for a while. Singing began the process of stimulating functional and structural neuroplasticity changes.

Gottfried Schlaug's Harvard lab published findings in *Frontiers in Psychology* in 2011 that showed that melodic intonation caused changes in a number of tracts in the brain's white matter–the gunk that promotes neural communication. The main change was particularly noticeable for a rather mysterious tract called the arcuate fasciculus, a fibrous neural pathway connecting all the language areas in the brain in both left and right hemispheres. In regular brains, this fiber tract is not well developed in the right hemisphere. After 75-80 therapy sessions, though, the number and size of each arcuate fasciculus fiber increases.

The entire therapeutic process involves four stages. In the first, the therapist hums phrases with an obvious rhythm that the patient replicates by tapping her hands or feet. In the second stage, the patient hums along with the therapist while keeping the beat. The humming progresses to sung words, which the patient repeats after the therapist in a call-and-response pattern. The fourth stage calls for a long delay between the therapist's intonation and the patient's, forcing the patient to recreate the sentence on her own.

The overall intention is to step down from singing to regular speech. Over time, after a lot of listening and replicating their therapist's singsong phrasings, the patient learns to rehearse what she wants to say aloud as song inside her head. Getting to a point where she can speak without first vocalizing a song is a matter of practice—calling for the same vigor and dedication that intensive training a musician undergoes to learn an instrument.

Despite the emphasis on melody in the therapy's name, neuroscientists have reached an unofficial consensus that rhythm might be the key in this therapy's success, the same as gait training. Through every stage of melodic intonation, the patient taps her left hand. The predominant theory is that the action primes the right hemisphere sensorimotor network that controls hand movements as well as mouth functions. Subconsciously making grand hand gestures while you talk might make sense now—they're on the same network. And tapping your finger in time to a song's beat is a lot like being your own metronome—only in melodic intonation, the rhythmic beat is the subtle one underlying spoken language.

Over time, with the help of a team of therapists, Giffords retrained her brain to use these different, re-strengthened pathways and organs to produce normal speech. Now cited as one of the most effective forms of music therapies, melodic intonation therapy—another NMT technique—allowed Giffords to respond to questions by singing her answers while tapping her hand to remind herself of the subtle rhythm in spoken language. Today, she can speak without needing to sing aloud.

Both gait training and melodic intonation therapy have results that are easily verified simply by visual observation, and a select number of neuroscientists continue to prowl the brain for the exact therapeutic mechanism. In most minds of the neuroscience community, the efficacy of these therapies is without doubt. The types of musical therapies that are less welcome with open arms deal with more slippery cognitive functions: intangible, mysterious memories, emotions, and spirituality. Even when acknowledging successes like gait entrainment and melodic intonation, most music neurologists opt to stand back from investigating other therapies with physical links that are less well understood or observable.

One of the common reservations that many neuroscientists have about general music therapy is that variables cannot be isolated in order to identify exactly what is helping a patient. Is it the social group setting most therapies provide? Are the movements required for nearly every therapy, the acts getting the blood flowing—are they responsible for some of the physiological benefits? And perhaps most immeasurable of all: how much depends on the therapist herself?

Ed Large, president of the Society for Music Perception and Cognition, was invited to be an advisor on the committee board for the Institute for Music and Neurologic Function in New York—the primary goal of which is to promote research for music therapy. He only agreed to join after participating in a drum group for stroke and gun wound victims, where he witnessed how "depression was at least partially gone in every face, it was something you could see, you could feel" and agreeing to the advising position. However, despite his support, he still voices reservations on pursuing research on the efficacy of therapist-established techniques for very practical reasons, and he thinks it's very reasonable for many neuroscientists to be skeptic.

"I don't even do research in it, that's how skeptical I am," he said. "I sort of leave it for others, because I like to do research where I can get results and I can say, 'Hey look, I found that something happens,' because"—and this is a familiar cause of hesitation in all fields of research—"it's almost impossible to publish a paper with a negative result."

Who are the "others" Large lets research in the music therapy field go to? Of course, there are the musical neuroscientists, like Harvard's Gottfried Schlaug. Then there's an obvious, largely untapped source quite intimate with the field already.

He had once posed the question, "How might we use music to rehabilitate memory?" to a neuroscience class he taught at Florida State University. He admitted with a laugh that, "We didn't come up with any good ideas. But it does seem like that someone smart enough and who's really engaged with that kind of patient population might come up with an idea that might actually work."

THE VOICE OF THERAPY

For Valentine's Day, Tow was holding a special group song-writing session. The activity calls for all participants to pitch ideas related to a particular theme and gets residents socializing without realizing how many autobiographical details they were sharing with each other. Last year, the group had written a romantic love song that had gotten many talking about loved ones who had passed away. Tow hoped for something similar this year.

Using music to stimulate memories is a common therapeutic intervention being promoted throughout North America. One of the programs that Ed Large's Institute for Music and Neurologic Function supports is called Music & Memory. NMT techniques like gait training and melodic intonation occur at any physical rehabilitation center so long as the therapist (Thaut's certification program doesn't require a musical background) is trained properly, but Music & Memory trains entire staffs at retirement homes or senior living centers on how to design and use personalized playlists to stimulate memories. Founded by social worker Dan Cohen and advised by music therapist Concetta M. Tomaino, Music & Memory had launched in 2008, and since then have trained roughly 60 such elderly centered institutions in 23 U.S. states, as well as 18 locations in Canada and England.

Though not funded by Music & Memory, Sherrill House under Dianne Tow offers many musical reminiscence or musical biography sessions that target people suffering from short-term memory deficits. Though Tow enjoys the conversations and stories that come out of those particular groups, she is well aware that the benefits are mainly comforting, not restorative.

"Really, our main goal in a nursing home is to improve upon or provide the most positive quality of life that we can," she said. "It's all about quality of life, all about being in the moment, particularly with someone with Alzheimer's. This is the only moment they have. They don't remember what happened before; they're not able to think about what's coming up next. They have this moment. It's really a privilege to jump into that moment with them, and just abide with them in that moment, and come what may."

Any neuroscientist will acknowledge that music is very good at evoking autobiographical memories (after all, don't we all remember a song or two from the high school years?), though they'll be cautious to note that the research behind music therapies aimed at stimulating long and short-term memories has a long way to go.

"Yes, music can help a patient to remember things, especially if they're reminiscing ideas, maybe to remember short-term information, like what day of the week it is or something," Thaut said. "But can you make a substantial reversal in the progression of the disease? No. That's probably up to some pharmacological treatment, in terms of the structure of nerve connections and nerve fibers."

The terminal nature of Alzheimer's or dementia hinders the kind of standardized, scientifically rigorous studies that would justify therapeutic efforts. To find significant results, music therapists would need to find a solid number of long-term participants and complete the study with low dropout rates—criteria difficult to fulfill with this particular population without interfering with care. They would also need to design a study that controls for mitigating factors that could be responsible for positive effects, and generally music therapists only have access to a small portion of their client's lives—even ones like Tow, whose office is basically in-house. But outside of the elderly population, neuroscience is investigating music's relation to memory in general, and the current research at least explains why music is one of the most tenacious memories that even an advanced Alzheimer patient can access.

Before Robert Zatorre of McGill University found in 2011 that the release of dopamine at key moments was (as with most pleasing things) involved in enjoying a rock ballad or sonata, musicologist Leonard Meyer in the 1950s had posited that the force behind music's emotional power lies in the way music subtly builds and destroys anticipation. David Huron, a more modern musicologist at Ohio State University, expanded upon this idea, noting that anticipation is a general cognitive ability that probably bled over from other skills, since listening to and predicting the movements of a hunted deer or a hunting wolf pack would have supplemented human survival.

Different emotions occur when predicting an event: the premonition, the actual occurrence, and the aftermath during which a person reflects on whether the projected event followed through to the letter or deviated completely. The emotions associated with the rumination stage can last for years. Evolutionarily, these emotions may have amplified success or failure, providing positive reinforcement for a correct prediction and negative reinforcement for a botched thought. From this standpoint, remembered emotions are not things to put on a mantelpiece and show to the neighbors every now and then. Rather, memories are important lessons and data points for a person to use in order to navigate the future more successfully.

A song, unlike the hunting sprees of yore, can be repeated note for note, replicated over and over again more perfectly than other human experiences—and, as Robert Zatorre's dopamine-and-music study showed in 2011, the effects of a good song usually feel positive. A popular radio song can ingrain itself in your mind without invitation, and each time it plays, it paces back and forth along the same route in your brain, creating a groove that can be rediscovered years later. Repetition over time moves music from the centrally located hippocampus (one of the first brain structures that Alzheimer's strikes) as short-term episodic memory to adjacent medial temporal lobes (often left alone by the disease) as longer, autobiographical memory.

Functional MRI images collected by psychologist Petr Janata at the University of California at Davies in 2009 showed how neural networks connecting the medial temporal lobes and the medial prefrontal cortex located near the forehead would spontaneously activate when a poplar song from a subject's childhood was played. Again, structural brain plasticity appears to be the key to music's efficacy: the neural networks that music appreciation involves act as alterative pathways to memory activation, rather than using explicit memory retrieval pathways that Alzheimer's may have corrupted.

So music lingers long in the brain, and interestingly enough, music may even help Alzheimer's patients to form new short-term memories the same way a schoolchild might use a simple ditty to memorize a slippery fact for a test. Neuroscientist Brandon Ally, now at Vanderbilt University, had performed a small study in 2010 while completing a fellowship at Boston University. He found that Alzheimer's patients could recall recently learned song lyrics as effectively as healthy controls. The lyric length that they could commit to memory didn't exceed four lines, so Ally predicted that Alzheimer patients could probably use this technique only for small daily tasks, like remembering which medicine to take. He was right—but his experiment encompassed a very small population. Further evidence with a larger sample size waits to be gathered, but the possibility is tantalizing for anyone who's watched a loved one lose their memories—and for healthcare workers who work closely with aging patients.

In Tow's sixteen years of working at Sherrill House, she has seen 100% turnover: not one of the residents who was there when she began was still living.

"I do form relationships, and so of course I'm affected because I've gotten to know them so well," Tow said, adding that, "But...allowing myself to make those connections is what allows me to reach them through that therapeutic level."

Conducting music therapy in a retirement home is quite different from other venues, such as an afterschool program for children who shy away from socializing or exercising, or a daytime rehab center for young adults and middle-aged patients. In a retirement home, death is as much a tenant as any of the residents—though a rude one, switching rooms or choosing new bedmates without asking permission. Tow herself has been present at many deathbeds, whether by request of the patient's family members or because she had figured that the time was near and wanted to provide some comfort for that resident.

"I've also always had a great respect...for my grandparents and for elders," Tow said as she finished preparing for the Valentine's Day songwriting session. "They've seen so much and they've been through so much, particularly this generation. They've seen depression...they've seen war, they've seen many wars, actually. And yet I've found this generation to be so graceful and giving. I think there's a lot to be learned from that, and to give back to them."

With an emerald green guitar in one hand and a large, three feet by three feet sheet of paper in the other, Tow briefly pondered bringing the bag of egg-shaped rhythm shakers with her to the session. She decided that for today's task, they aren't necessary; the song that would be written wouldn't be set to music until next week.

The song writing therapy group has two main purposes. The obvious one is to increase socialization by providing a comfortable forum for residents to stimulate memories and share stories. The second, subtler goal is to alleviate depression.

The National Institute of Mental Health and the American Psychological Association describe depression as the most common mental disorder nationwide, but considered still very serious. Everyone suffers from depression in brief spates throughout their lives, but without treatment, severe depression can have physiological effects that can prevent patients from functioning normally and enjoying life—including immune response impairment, withdrawn communication, feelings of worthlessness, and increased mortality.

Treating depression has evolved wildly in the last century. Prior to the 1950s, people dosed themselves with opioids and amphetamines. Then came the rise and fall of trans-orbital lobotomies (because cutting your frontal lobe with an icepick jammed through your eye sockets was once considered a reasonable solution), the still-popular if now-debatable psychotherapy (because talking really can't hurt you), and the advent of the chemical lobotomy: prescribed antidepressant pills, which can still be a hit or miss. In very severe, unresponsive cases, patients have resorted to brain surgery and implants.

Addressing a person's emotional and spiritual needs in the field usually calls for a combination of research-based methodologies and non-standardized clinical experience. Many music therapists, as well as family members close to people with failing health, have reported that musical expression helps depression, whether through improvised and deliberate instrumentation or lyrical compositions. However, the neuroscientific and psychological proof for music's efficacy is spotty—after all, severe depression has rendered even music less enjoyable for some people. A 2009 review performed by music neuroscientist Stefan Koelsch of Berlin's Free University, whose research includes the neural correlates of emotion and music, reported in *Trends in Cognitive Sciences* that despite recent revelations in the past decade on emotions and music, "different roles of various brain regions involved in emotion are still not well understood" and that "only little is known about the neural correlates of different psychological processes underlying the evocation of music."

A contemporary review from the music therapy community, spearheaded by therapist Anna Maratos of the Central and Northwest London Foundation NHS Trust, found that the even the best studies on depression suffered from poor reporting on key data gathering methodologies. Emotional inventories were not standardized, and who knows how consistently they were even administered. In some cases, paper authors could not provide details about how they controlled variables, or even what variables were present—whether or not a patient was simultaneously undergoing psychotherapy, for example. But optimistically, the fact that therapists tried to conduct studies still showed potential. Given that therapists would get better training on how to create and conduct a scientifically rigorous study, Maratos believed that the case for music therapy on depression could still be built.

Since the late 1960s when the two disciplines stood shakily on their feet, neuroscience and music therapy have worked separately until much more recently—Harvard's Music and Neuroimaging Lab, for example, began employing music therapists in their investigation of melodic intonation. The general lack of collaboration between the two professions seems to derive from differing methodologies and goals.

The path to becoming a music therapist begins with a love for music and an equally strong interest in helping people. In college, the curriculum entails a combination of social work, music, psychology, and behavioral biology. Tow's program, for example, required her to play an instrument in every classification—percussion, string, woodwind, brass, and voice—while learning practical social work knowledge through an internship. This kind of education prepares students for the clinical world but does not train them to think like a scientist—and in most cases, this is totally fine and expected. The skills to design and carry out an experiment are not necessary to be a good music therapist.

But there is a movement to improve music therapy's repertoire of evidence-based practices, and so now there are therapists who have designed and pursued a doctoral degree in music therapy research. Krystal Dermaine at Leslie University, for example, now works with Harvard's Music and Neuroimaging Lab to help decipher melodic intonation. Blythe LaGasse at Colorado State University rubs shoulders with Michael Thaut, the guru of gait training, and runs a project focused on educating music therapists on vigorous research methods. But the integration between therapist and neuroscience research is still trying to find a foothold amongst contrasting research goals, difficult population parameters, and a longstanding occupational bias.

Music therapists witness music's effects from the outside. Often by trial and error, they find how one patient responds better when given a drum to play when another will perk up at the first notes of an old favorite song. They observe how a petulant child can calm down while banging a drum, or how a former drug addict can channel their energies into composing personal lyrics with a catchy tune. But very few therapists have the resources or funds to their patients to a MRI or CAT machine to see how the therapy affects the brain, and doing so could also impact the patient's recovery. Their ultimate goal is providing personalized rehabilitative care, and understanding why individual therapies work is not entirely necessary to be successful. So therapists like Tow may be informed by scientific research but in practice will test out different things for each patient until the treatment is tailored beyond experimental replication.

On the other hand, neuroscientists are driven by the how and why of music, and so their subject of inquiry is the brain's regular function, not treating a malady—though understanding regular functions can lead to treatments, the way gait training was born. The depth to which their understanding goes is amazing. They have produced detailed, real-time images of blood flowing around the brain while listening to music. They have gathered EEG data to determine that music drowns out beta oscillations in the basal ganglia. They can produce gigantic images of their patients' brains, overlay blood flow with electrical activity and make correlations to predict what could be happening. But until genetic tools and imaging methods can isolate the function of each individual brain cell—the goal of the Human Connectome Project, the neuronal version of the Human Genome Project that mapped individual genes—neuroscientists are still guessing at psychological and emotional effects.

The patient responds to a pleasant song; a cluster of neurons fire. The therapist does not know if the patient feels better because the rhythm, melody, or pitch of the song are causing a pinpoint physiological effect; the neuroscientist doesn't know which specific neuron set off the reaction or to what end that specific reaction may accomplish. They only know that *something* happened—though certainly they will continue to learn more, separately, and together.

Tow's rapport with the Sherrill House residents was clear at the start of her song-writing session. After taping the paper square she had brought at the front of the room (an architectural mirror of the atrium where the sundowning group had been gathered one floor below) she walked down the residential hallway, knocking on doors and asking residents if they'd like to write a song with her today. She knew every resident by name.

"Today we're going to write a song about love," she announced when they were gathered. "Now, I'm going to give you a choice. We can write about romantic ooshy-gooshy love, or we can write a general love for humanity. Which will it be?"

The residents were mostly quiet. The personalities that piped up with their vote—"A general love, let's do that"—ended up being the most vocal all throughout the song writing session, which began with Tow coaxing ideas out of people and writing them down on half of the paper she had taped on the wall.

One of the residents was an 80-year-old man named Roger. He arrived late, carrying his own chair to the back of the room without aid. For much of the session, he remained quiet, even though he nodded along when he liked something being discussed or written up on the paper. Halfway through the discussion, just as Tow started to synthesize raw ideas into actual lyrics, he volunteered one thing.

"I think the love of someone is praying to God when they is ill and they're not getting better and dying, to ask the Lord to let them die," he said. "I think that's real true deep love."

Tow nodded. She repeated Roger's words for the hard of hearing, and a chorus of agreement sprang up from around the room. Sounds of sympathy and understanding emerged from others in the group. More personal stories spilled out as Tow reworked ideas into rhyming couplets. She read the lines aloud for them, in case their eyes were too weak to read what she had written, to get their approval and incorporate more suggestions about the wording. Without needing Tow's encouragement, residents were telling stories and laughing with one another.

After about 20 minutes, the song appeared to be finished. Tow read it aloud in its entirety, and the room cooed with approval. She thanked them all for composing such lovely lyrics and decided right then and there that she was going to write an original melody for them and sing it for them next week. And, she added, Roger was going to help her.

Roger chuckled quietly, looked down at his hands, and said nothing.

The questions scientists ask about how music works refer to the details, the physiological and psychological reasons. But there's also the bigger, evolutionary "why": why did humans develop such a complex appreciation for sound that listening to artful arrangements affects brain pathways, motor functions, and speech patterns?

Cognition scientist Stephen Pinker famously called music "auditory cheesecake," saying that humans developed a taste for pleasant sounding tones and sequences by an accidental convergence of various cognitive functions developed for separate reasons. As unromantic as this idea is, current music neuroscientists like Aniruddh Patel of Tufts University tend to support this idea–if through a more pragmatic lens. In theory, recognizing each musical element has a survival function by itself. Volume plotted the vicinity of a predator, pitch helped recognize the roar of a smaller lion versus a larger lion, melody placed sounds into sequences, and rhythm lent predictability to interactions.

Patel, following in the footsteps of the ever-thoughtful Charles Darwin, is on a mission to find the ability to distinguish individual musical elements in other animals. This plots the evolution of human musicality. When drastically different species can distinguish a particular musical element, the earlier its corresponding cognitive function developed in the grand evolutionary story. Volume perception, for example, appears in animals as distant as reptiles and insects, while rhythm is noticeably absent in distant relatives or only mildly pronounced (most notably the cockatoo Snowball, whose ability to dance still flummoxes Patel). This evolutionary spectrum breaks down human appreciation of music as a whole along a long stretch of centuries.

But is this temporal map enough to explain why we appear to have cultivated our theoretically accidental appreciation for sound, to the point that our enjoyment transcends races and is only absent in a tiny percentage of humans?

Music has played a strong role in community bonding around the world for centuries. Nearly every culture, tribe, and civilization has used music to bring communities together, to excite spirits into dance and celebration. From drum circles in Africa to the Bollywood productions of India to the trance DJs of Europe, we have used a beat and a melody to get moving, physically and mentally. Bonding in groups is, of course, a great idea in a dog-eat-dog-world where even strong, healthy loners would be a better target to a hunter than a group of virile individuals. But animals keep in groups just as well without holding concerts, musical shows, dance parties, or drum circles—at least, nothing so coordinated and harmonized as an orchestra or symphony. Did our ancestors develop a need for music to bond us together as a whole—as a species, rather than separate packs?

The feeling of being connected to something bigger than the individual is what defines spirituality, the last health domain that therapists address. A woman singing hymns and swaying with the choir, the mosh pit rocker, and a concert pianist in the throes of a performance can all attest to music's ability to move us and connect us to each other. Even if we had no part in a song's creation, that song can bind hundreds of people together with shared experience. Unexplained by science and therapists alike, music has the power to unite us with the people physically present around us, the absent friends whose presence music recalls, or whatever god you might choose to serve—giving us the sense, at least, that perhaps we're not as alone as we may sometimes feel.

A week after Valentine's Day, the song-writing group reconvened. As the participants settled in to their usual spots with a few new curious faces finding a place of their own, Roger stood at the front of the room plucking out chords and little ditties from the large Casio Privia keyboard Tow had brought up from the solarium. The evening before, Tow had brought the same keyboard to his room, and together they had composed a simple little melody for the lyrics the group had written.

Roger had been a concert pianist before retiring, so reading music and performing on an instrument was nothing new. But the act of composing an original song, which he had never done before, brought him to tears.

"I thought this was a talent I didn't have," he had told Tow. When she played the whole thing for the first time during their composition session, he raised his hands, mimicking a conductor's stance, swaying back and forth and smiling.

At show time, he was much more talkative than in the composition session. He sat near the front, almost impatient for the session to begin, and struck up a conversation with the woman next to him, a 100-year-old woman named Sarah. Quite a few of the lyrical lines in the song had sprung from her suggestions.

"Dianne helps me get to a place where I can talk," Sarah said, nodding slowly but emphatically.

"She's the one who got me playing," Roger said. He pointed down the residential hall, where Tow was knocking on doors and greeting residents, emphasizing his next words with rhythmic jabs. "She is awesome. She. Is. Awesome."

When everyone was finally gathered, the room buzzed with small conversations. "I've been waiting to hear the music," Sarah told Roger. "I didn't know you were a pianist!"

Tow handed out paper copies of the lyrics so that they could follow along and perhaps sing if she repeated the song. At the top, big bold letters proclaimed that the lyrics were written by the third floor song-writing group and the music was written by Roger and Dianne Tow. Tow announced that Roger had done most of the work (though he protested) and launched into the song, playing from memory:

> Love is not all happiness and kisses
> It's got its ups and downs, its hits and misses
>
> But love means forgiving and accepting faults
> Sometimes love is letting go even when it breaks our hearts

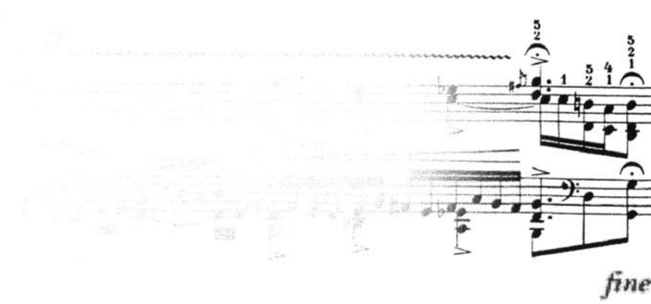
God didn't put love in our hearts to stay
Love isn't love until you give it away.

"It's wonderful," Sarah said, looking at Roger in astonishment. Other voices weighed in: "That's really good!" "Lovely!" "Beautiful!" "Play it again!"

"We should have a baritone section," someone joked. The room laughed. Mostly everyone in the room was female except for Roger—who was smiling from ear to ear, aglow with delight. From the look on his face, he could have just performed the show of his life.

Tow finished playing the piano. After the session, I asked her if she would stop what she was doing if science declared music therapy to be ineffective in treating neurological problems like Alzheimer's. She shook her head. Sixteen years singing to the fading memories and ears of the elderly had done little to wear her enthusiasm and empathy out.

"Science won't find that," she said. "I see the results every day. Music elevates their moods, it boosts self-confidence. I would never stop doing this."



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Sheet music image: "Komm, Gott Schopfer, heiliger Geist," J.S. Bach.