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Music in Our Brain: Music as a Central Cognitive Property
It is becoming increasingly apparent that the arts are central to the development and maintenance of our brain. Regulating movement in all of its physical, psychological, and communicative manifestations is a key cognitive task—and the arts encourage us to move with style and grace.

Communication is an obviously essential property of all social species. Many social species (including humans) use two basic forms of communication, (1) a personal intimate form called grooming or caressing that uses touch and body language to establish and maintain bonding and hierarchical relationships within the group, and (2) a more complex auditory signaling system that alerts others in the group to the nature, location, and importance of potential dangers and opportunities. In primate signal systems, a single cry carries all the pertinent information, and the system is innate. A baby monkey who has never heard the sound for danger overhead (such as a circling hawk) will thus look up in fear if you play a recording of that sound.

Human Communication

Human language is the most extensive and complex of all the communication systems. Although we use about the same number of phonemes that many primates use in their signaling systems, human language communicates much more information. We do this by taking the meaning out of the sounds, and inserting it into the sequence and length of a chain of sounds (such as in do, dog, God, good, goods). Thus, 44 meaningless phonemes (and their 26 alphabetic equivalents) can create an English language of 500,000 meaningful words. Further, word sequences create sentences, and sentence sequences create narratives.

We can similarly create an infinite number of melodies out of the 5–12 tones of the various musical scales because a melody emerges out of the sequence and length of a chain of tones, and not out of the tones themselves. We can similarly create an infinite number system out of ten digits because 123 doesn’t represent the same quantity as 321.

Genetics as Communication

What’s even more amazing is that the 20 elements in genetic communication function via a similar sequential coding system. The nucleus of a plant or animal cell is composed principally of a long, ladder-shaped, twisted molecule called deoxyribonucleic acid, or DNA. In humans, some 30,000 DNA segments (called genes) regulate cellular processes and initiate the assembly of proteins, the basic building blocks of our body. A gene contains the coded directions for assembling a protein out of a unique sequential combination of the 20 different kinds of amino acids that cell bodies contain. Different amino acid sequences result in different proteins, just as different tone sequences result in different melodies.

So at conception parents combine their genetic sequences to inform their embryonic child how to develop its body (nose placement, skin color, gender, and so on)—in effect, how to become a human being. And then when the child is born, the parents use language and musical sequences to tell their child how to behave like a human being. It’s an incredibly beautiful arrangement.

The Key Role of Musical Communication

Mastering one’s native oral and written language is an extended major childhood task, and current school standards and assessment programs focus principally on the development of such skills.

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Unfortunately, we’ve tended to narrow our definition of language. For example, most K–12 schools currently focus on mastering the sequence of letters that constitute a word but not also on the sequence of tones that constitute a melody, on the grammatical structure of language but not also on the structure of musical forms, on the ability to use writing and typing tools but not also on the ability to play a musical instrument.

It’s not that music isn’t ubiquitous in our culture—but it’s become a one-sided message that emanates from stages, loudspeakers, and personal portable pods. We tend to listen to the music of others rather than to create our own. I suspect that most folks who sing at all during a given week do it only during religious services—and while liturgical singing is corporate, it typically isn’t conversational.

Articulate speech compresses an extended thought into a stream of rapidly moving phonemic sounds that transmit information. The spoken message identifies key objects (nouns) and events (verbs) that are then clarified by adjectives and adverbs, and syntactically positioned by prepositions and conjunctions. Variations in volume and tone are typically reduced in order to increase the flow of information.

Conversely, song communicates how we feel about something. Song communicates a short but emotionally strong message of love or hate, of commitment or alienation, of opportunity or danger by slowing down the flow of the message (extending the vowels, repeating phrases). This permits the singer to use such musical properties as melody, rhythm, volume, timbre, and instrumental accompaniment to insert powerful emotional overtones into such primal messages as ‘I love you’ or ‘I reject war’ or ‘Don’t abandon me.’ Such emotional overtones are much more difficult to insert into speech. Adjectives and adverbs are typically a poor substitute for musical properties.

It’s intriguing that children spend much of the first 10 years of their life mastering the vocabulary and syntax of oral and written language—the knowledge and skills they must develop in order to communicate effectively with others about complex personal and cultural phenomena.

Conversely, adolescence is probably the single decade in our life during which we’re most fascinated by music. It’s not surprising that this is also the time during which we develop our personal and social identity, our likes and dislikes.

We thus have two complementary languages. Speech helps us to rapidly and articulately communicate a lot of information to everyone. Song helps us to slowly and melodically communicate personal feelings, beliefs, and commitments to those who mean the most to us. Reading the Gospel account of Christ’s life isn’t the same experience as listening to Handel’s Messiah.

It’s important for young people to be grounded in the grammatical structures that enhance verbal communication, and it’s equally important for them to become grounded in the grammar of music. Instructional programs that teach instrumental music and choral singing are examples of how to provide children with musical skills and a sense of the structure and aesthetics of music before they embark on their musically driven adolescent search for personal and social identity. Without such instruction, adolescent music becomes improvisational variations on an unknown theme. There’s nothing wrong with musical noodling, but there’s something right about helping young people to understand the underlying structure and dynamics of music.

Young people learn to communicate effortlessly via conversation and computers, but as suggested above, many schools seemingly don’t consider music an integral element of language. The reduction (and even elimination) of school music instruction is an enigma, given its ancient human roots and current cultural ubiquity.

Scientists have discovered 50,000-year-old flutes made from bear bones—and a flute is an advanced musical instrument. Further, adults have long and universally interacted with infants via a musical form.
called motherese—a high-pitched, exaggerated, repetitive, melodic format that engages the rapt attention and mimicked response of infants who can’t understand the words. Music thus introduces infants to speech by preparing their brain to effectively process its complexities and improvisations.

**Mirror Neurons**

The remarkable recently discovered mirror neuron system enhances the developmental process. Most common actions are actually sequences of basic movements that are used in various actions. Think of the sequence of movements in which you reach out, open your hand, grasp a glass, and lift it to your mouth. Reaching, grasping, and lifting are used in many different actions, just as the letters d-o-g can be used in the words do, dog, God, and good. Our brain’s memory networks thus store and retrieve common movement sequences just as they store and retrieve verbal and musical memory sequences.

Scientists discovered that mirror neurons that store, prime, and activate specific action sequences also activate when we observe someone else carry out that action. In effect, our brain activates the same neuronal pattern that’s activating within the brain of the person we’re observing. It thus understands what’s going on in the mind of the observed person, and so can automatically activate a mimicked response (think of our tendency to yawn when we see another person yawn). Stick out your tongue at an observant infant who is only a few hours old and she’ll reciprocate, even though she doesn’t consciously know what a tongue is or how to project it.

Life would be chaotic if we mimicked every behavior we observed, so our brain’s inhibitory system turns off inappropriate responses. We’ll thus stifle a yawn but reciprocate the proffered handshake of a friend. Infants have a zillion actions to learn, however, so they tend to imitate everything they see. Smile and they’ll smile; wave your hand and they’ll wave their hand. It’s baby see, baby do.
Learning to Speak and Sing

Mirror neurons thus help to explain how infants who interact with adults can easily learn movements they haven’t made before, such as the complex facial and vocal movements that process song and speech. We can observe arm/leg movements but not a speaker’s hidden vocal apparatus. Our sensory/motor system is highly interconnected, so we can visualize a named but non-visible object, such as a banana. Similarly, hearing articulate speech or song activates the same vocal processes in the child’s brain that the speaker used to sequence the sounds and words. Speech is a complex motor activity, so the infant initially babbles incoherently. The child will eventually begin to correctly utter simple phonemic combinations in a verbal environment, and finally smooth articulate speech and childhood songs emerge. The Suzuki violin program is also partially based on this observing and mimicking principle.

When we observe someone in the initial stages of a movement sequence, such as when a diner picks up a knife and fork, we can infer the subsequent actions because our brain is mirroring the entire movement sequence and so infers what will occur next. When a speaker stops mid-sentence, we can often complete the sentence. If someone begins a familiar song, we can easily continue it. Think of how your computer will complete a frequently used email or Web site address after you type the first few letters. Our brain similarly remembers entire sequences. The alphabet is one of the more remarkable memory sequences that young children easily master. The 26-letter sequence has no inherent logic to it—and yet young children easily master it when it’s inserted into a more easily remembered melody.

Affective Mirror Neurons

Since our brain’s hundreds of processing systems are highly interconnected, mirror neurons not only simulate the actions of others but also their related properties, such as the pain or pleasure that results from an action. We use the term empathy to describe this human ability to internalize the emotional state of others by simply observing their facial expressions and body language.

Several frontal lobe systems collaboratively process pain—but mirror neurons in these systems copy and respond to the observed pain and other emotional states that people we observe are experiencing. Empathy can further emerge through third party reports, such as news reports of the victims of natural disasters or accidents. Listening to a highly emotional musical performance can similarly result in a mirrored emotional state.

Mirror neurons may also help to explain why so many of us enjoy observing and predicting the movements of virtuoso musicians, athletes, and dancers. Virtuoso performances allow our mirror neuron system to mentally model (and thus enjoy) actions that we can’t physically mimic at that level. Note the related actively imitated body language of former athletes as they observe a game they once played, and their ability to see individual movements within the complexity of the action that the rest of us don’t see. This is also true of the differences that trained musicians and naïve listeners exhibit in their ability to critique a musical performance. The naïve listener can only express feelings, but a musically trained person can analyze the subtle dynamics of the performance.

Improvisation: Going Beyond Mirror Neurons

We can think of reading narratives and musical notation as a symbolic extension of our mirror neuron system, in that we mentally and physically replicate the thoughts of the writer or composer. Musical improvisation is a different kind of activity.

Researchers have recently observed what occurs within the brain of a jazz musician during improvisation (Limb, 2008). They saw significant changes in activity in the prefrontal cortex (PFC) during improvisation as compared to when the musician played memorized music. The prefrontal cortex (directly behind our forehead) is where we process problem solving and develop our
sense of self. During improvisation, the section of the PFC that monitors one’s behavior shuts down, and the section that processes self-initiated thoughts and behaviors increases its activity. The researchers suggested that just as over-thinking a jump shot can cause a basketball player to miss the shot, so suppressing our inhibitory self-monitoring brain system helps to promote the free flow of novel ideas and impulses. Our sensory and emotional systems also increase their activity during improvisation, so it seems to be a matter of our entire brain moving to a higher activation state. The result is creativity—either the creation of new musical forms in improvisation, or else in the creative expression of an existing musical form in a virtuoso performance.

A young adult recently said that he looked for two things in a church—that it would give him a welcoming hand, and a creative beat. I’m thus left wondering how a supposedly enlightened culture like ours could consciously neglect the development of a definitive brain property. Spoken and written language are obviously superior to music in the transmission of information, but music trumps adjectives and adverbs in the transmission of qualities and feelings. Further, we began life with the music of motherese, and we often return to music when words alone fail us. The majority of a church service is devoted to activities that incorporate musical and gestural activities, and yet these are afterthoughts at best in most current K-12 school programs.

We truly need to develop both forms of language to be fully human. Do folks really believe that knowing how to harmonize or play an oboe or improvise jazz or analyze a symphony is innate? Do such folks also believe that language is only about knowing, and not also about feeling?

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