by Shawn Carlson

Dissecting the Brain with Sound

In the summer of 1893 Arthur Nikisch, then Europe's premiere conductor, popped in on the legendary composer Pyotr Ilich Tchaikovsky to talk a little shop. According to Nikisch's assistant, Richard Lert, we know only one thing for sure about their get-together: Nikisch didn't like the way Tchaikovsky had scored the finale of his Sixth Symphony (the *Pathétique*), and he adamantly wanted the maestro to change it.

The contentious passages were certainly unorthodox. Tchaikovsky alternated the main theme and accompaniment between the first and second violin sections; as a result, each section played every other note of each theme. Nikisch wanted Tchaikovsky, who was preparing the piece for public debut, to rescore the movement so that the first violins would play the main theme alone, and the second violins would play only the accompaniment.

No one knows why Nikisch opposed Tchaikovsky's score so intensely. He may have rehearsed the *Pathétique,* and it's tempting to believe that he did. If so, Nikisch's musical ire might have been aroused by a peculiar and newly discovered facet of human perception.

The odd score hardly affects a listener today, because the first and second violins sections sit together; the listener hears both themes coming from the same region of the orchestra. But 100 years ago orchestras were arranged differently. The first violins sat on the conductor's left, and the second violins on the conductor's right. Standing in the center, Nikisch may have felt as if he were being battered from both sides by two disjointed sets of sounds that did not integrate into a harmonious whole.

I say "may have felt" because (here's that peculiar facet of perception) people don't all hear music in precisely the same way. In fact, according to Diana Deutsch, a professor of psychology at the University of California at San Diego, how we perceive certain sound patterns depends on our native language and whether we are right- or left-handed. Even our dialect matters: people brought up in California tend to hear certain sound patterns quite differently from those reared in England, for example.

The *Pathétique*'s contentious measures are an example of this kind of pattern. Most people's brains blend the violins' voices into Tchaikovsky's intended melodies. Nikisch's singular genius for conducting, however, suggests an extraordinary precision at discerning patterns in sound. He may have objected to the score because his ear was not fooled by the illusion.

Today these mysterious illusions can serve as sonic scalpels for dissecting the brain and discerning some of its inner workings. Until now, only a handful of professional scientists have been able to wield them. But no longer. Deutsch has just created the first collection of audio illusions on compact disc. Skillfully narrated by Deutsch herself, "Musical Illusions and Paradoxes" will let you experience some striking sonic chicanery (Philomel Records, Box 12189, La Jolla, CA 92039-2189; telephone: 800-225-1228; fax: 619-453-4763; Web site http://www.philomel.com; $14.95 plus $4.95 shipping). What is more, armed with this CD, any amateur scientist can conduct original research on how the brain processes sound.

I recently visited Deutsch's laboratory and got to experi-

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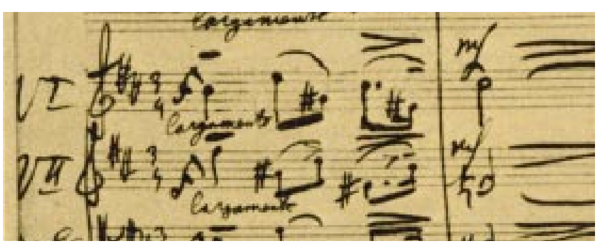

GLINKA MUSEUM, MOSCOW

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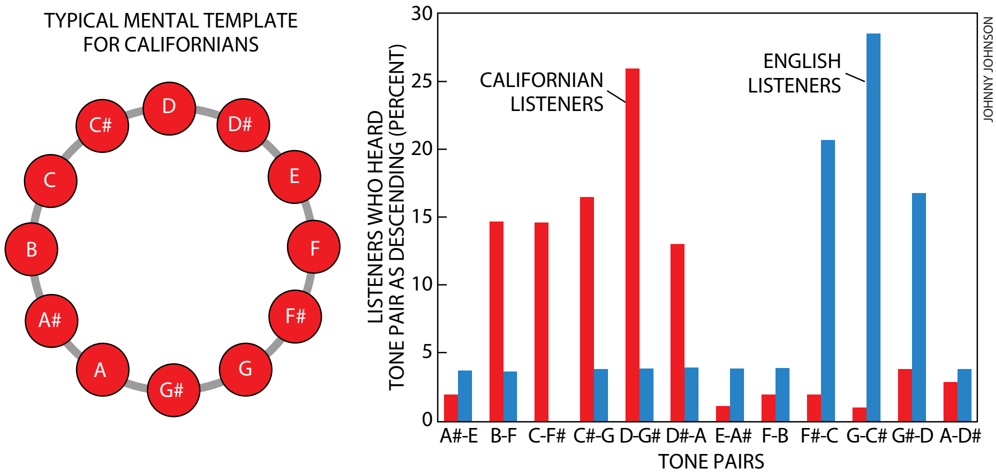
CONDUCTOR VERSUS COMPOSER: conductor Arthur Nikisch (top) *rescored part of the* Pathétique *so that the first violin plays F, E, D, C, B and the second plays B, A#, G#, E#, E. The original, by Tchaikovsky* (right), *shown in his own hand, has the first violin playing B, E, G#, C, E# and the second F, A#, D, E#, B. Nikisch's objection may have resulted from a peculiar aspect of the human perception of tones.*



RESULTS OF THE TRITONE PARADOX *suggest that people form a fixed mental template that places ambiguous musical tones (those without any octave information) in a circle. For Californians, ambiguous tones constructed from B, C, C#, D, D# tend to fall in the upper half of the circle, so that tone pairs B-F, C-F#, C#-G, D-G# and D#-A are heard as descending. For Britons, the opposite tends to be true.*

ence these illusions firsthand. My initiation began with the octave illusion. Through stereo headphones, she played me a simple pattern: two notes one octave apart alternating from ear to ear so that when the higher note was played in my right earphone, the lower note appeared in my left, and vice versa. But that's not at all what I heard. Rather I perceived a pattern that alternated between a single high note and a single low note with the high note always appearing in my right ear and the low note always appearing in my left.

This, Deutsch insists, makes me a typical right-hander. We righties tend to be dominated by the left hemispheres of our brain. Most of the signals from my right ear shoot over to my left hemisphere, where neurons decipher their pitch, and my weaker right hemisphere predominately processes signals from my left ear. Then, a separate bunch of neurons deciphers where sounds originate in space. These neurons tend to rely on frequency to localize sound and thus assign the source to whichever ear receives the higher pitch. That, coupled with my left hemisphere's dominance, creates the paradox: when the high pitch enters my left ear, I can't hear it at all, and I localize the pitch I do hear (the low pitch) in the wrong ear.

People with more equally balanced hemispheres than I have (most left-handers and some right-handers) hear the illusion differently. In fact, left-handers are equally likely to hear the higher tone in either ear and are twice as likely as right-handers to hear more complex patterns in which notes change pitch or the higher tone shifts from ear to ear.

Lowering the right earphone's volume decreases the stimulation inside the left hemisphere and thereby tilts the scales toward the right hemisphere. At some point, the illusion changes for even the most left-brained right-hander. The same trick might suddenly cause a hemisphere-balanced lefty to perceive the illusion (no one has tested the possibility yet). The difference in volume between the two earphones required to change the subject's perception provides a measure of hemispheric dominance.

Volume control is in this way your first sonic scalpel. Set the level on the soft side. Adjust the balance knob on your stereo amplifier until the illusion just changes. Then using a sound meter (check your local Radio Shack store), measure the sound intensity in each earphone. Repeat the procedure several times and average the result. Plot a histogram of this average (see April's column for information about histograms) for about 30 righties (or lefties), and you will discover something fundamental about the way brains of right-handers (or left-handers) are structured.

Deutsch's so-called tritone paradox presents more research opportunities. The paradox uses computer-generated tones constructed from the same note (say, D); each tone effectively consists of all the same notes spanning five octaves played simultaneously [*see illustration on opposite page*]. The result is ambiguity: people perceive the tone as a D but disagree as to which octave it belongs. The paradox comes about when a second, similarly crafted tone is played immediately after the first. This second note lies half an octave, or one tritone, away—equivalent to a musical distance of six semitones (or six piano keys, including the black ones). So after the D tone is played, a G-sharp tone would follow. Because neither note has any octave information, there is no clear answer as to which note is higher in pitch. Some people insist that the G-sharp is lower than the D; others hear it as higher.

According to Deutsch, how people perceive this paradox depends on where they grew up. Californians tend to hear the illusion in a manner completely opposite to people from the south of England [*see illustration above*]. Furthermore, children tend to hear the paradox as their mothers do. Apparently, the dialect that one grows up hearing affects how the brain resolves these tones.

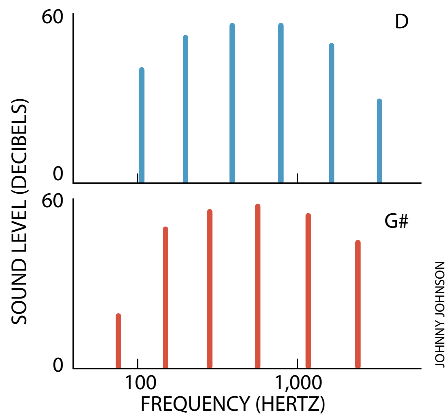
Actually, few data exist on this effect. How do folks from Maine, or Tennessee, or Nova Scotia, or South Africa respond? Do different generations show different responses? No one knows. By recording your friends' responses to the tritone paradox, you can make a real contribution to science.

My absolute favorite treat from Deutsch's CD is the high-low illusion. Deutsch first recorded the words "high" and "low." She then laid down a continuous stereo track in which the words alternate at a dizzying pace back and forth between the speakers. The result is a pattern that sounds like language, but the words are not quite recognizable.

Within a few seconds of listening to this strange cacophony, my brain started imposing a shifting order over the chaos as I began hearing distinct words and phrases. First came, "blank, blank, blank." Then "time, time, time." Then "no time," "long pine" and "any time." I was then astonished to hear a man's voice spilling out of the right speaker only. In a distinct Australian accent, it said, "Take me, take me, take me!"

This illusion suggests more avenues for exploration. See if your subjects' responses correlate with their beliefs or state of mind. That may reveal fresh insights into how attitudes affect our perceptions. Or measure how long it takes for your subjects to hear "play time" after you suggest it. Let me know what you find.

By the way, Tchaikovsky, who died a few months after the meeting, refused to give in. Nikisch rescored the contested passages anyway and thereby created a separate school of performance for this symphony. A few modern conductors still side with Nikisch and use his revision in their performances of Tchaikovsky's *Pathétique*. SA



***AMBIGUOUS TONE PAIRS** are made by combining several notes. Here D and G# tones that are ambiguous in octave each consist of six D and G# notes from other octaves (as measured in terms of frequency).*

The Society for Amateur Scientists, in collaboration with Diana Deutsch, has developed an experimenter's package to help amateur scientists contribute to this field. It includes the CD, a cassette tape to test perceptual ability, detailed instructions and data sheets that will enable you to conduct original experiments and even collaborate directly with Professor Deutsch. Send $24.95 plus $5 shipping to the Society for Amateur Scientists, 4951 D Clairemont Square, Suite 179, San Diego, CA 92117. Additional information can be found at http://www.thesphere.com/SAS/