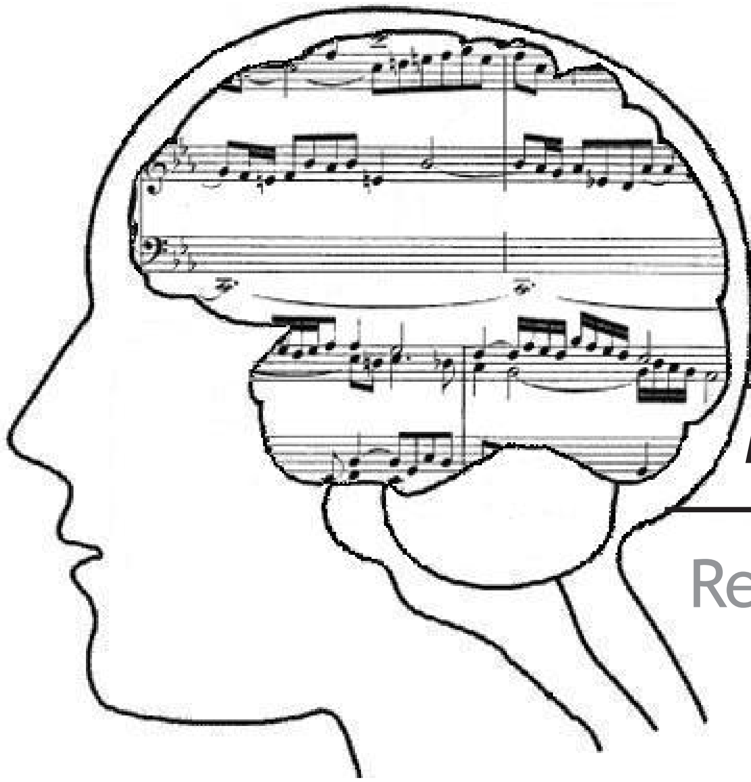


Music on the Mind

Research in Musicology and Cognition

By Katie Banks

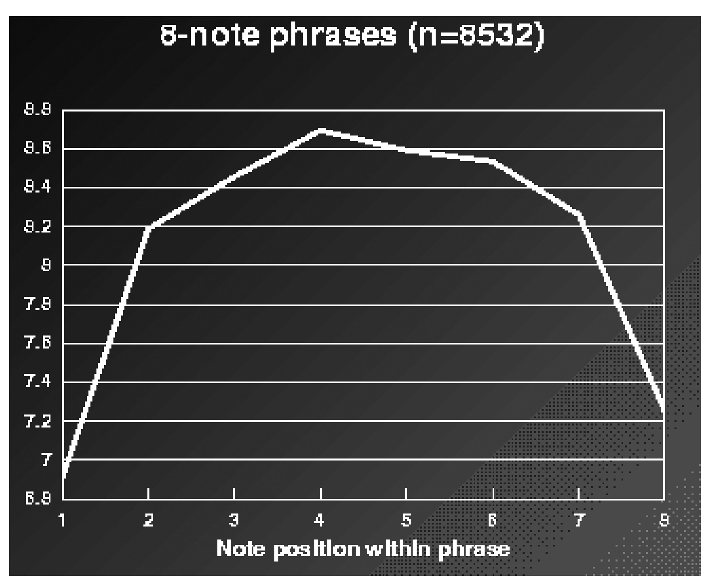
What if we could take a recording from any music tradition in the world and generate a usable score for it automatically? What if we could take the field recordings done by musicologists over decades and analyze all of them at once? What new sonic landscapes are open to composers, who can now control every harmonic in every note they sound? What does musical structure tell us about the structure of our minds and languages? How did music evolve?

These are just some of the pressing questions driving interdisciplinary research in musicology, neuroscience and psychology in the past two decades, as scientists and musicians supplement clinical case studies and ethnography with robust statistical analyses of large data sets.

Empirical Musicology

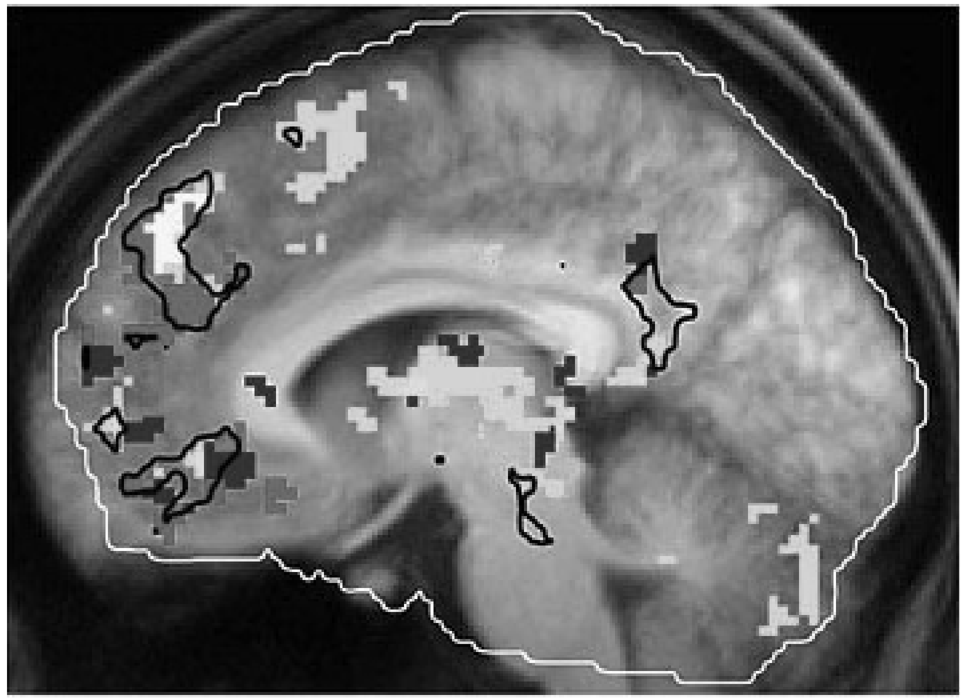
David Huron of Ohio State's Cognitive and Systematic Musicology Laboratory developed the HumDrum toolkit, a scripting language for encoding music and searching for patterns within it. Researchers around the world have discovered, using this software, that European folk songs have a characteristic melodic arch shape; showed that a computer can be trained to automatically classify works as mostly monophonic, homophonic, or polyphonic; empirically verified the common music-theoretic idea of constant "complexity" by showing that as tempo increases in Haydn's string quartets, rhythms and harmonies become simpler; and studied the effect of a new instrument's invention on melodies and harmonies in Cajun music (1). There is a hitch: most of the music has to be hand-coded into the system. We're still a long ways away from the holy grail of a good transcription system for all world musics, limited both by computer algorithms and the lack of any notation system for many of the world's musics. But with HumDrum, even music never before written down can be encoded and studied systematically.

Huron has used his large data



▲ **Figure 1.** Huron found this characteristic arch shape to the melodies of thousands of European folk songs, corroborating the music theory idea of melodic contour with scientific evidence.

credit: http://musicog.ohio-state.edu/Huron/Publications/huron.arch.text.html; musicmindandbrain.wordpress.com sets and experiments to confirm certain things that musicians find intuitive: among his findings, that pieces in the minor mode are usually slower (except in the Romantic period) and a breaking voice in country music is correlated with grief-related lyrics (10, 13). This sort of analysis seems pedantic to many musicians: but in any young science, it's important to establish a rigorous methodology and a foundation that agrees with what we observe. This is so even for the most "trivial" observations—especially for a new science that bridges disciplines with "postmodern" versus "empirical" methodologies. And already Huron has found groundbreaking new things: he's derived the rules of Western common practice voice leading from a few basic perceptual principles, in the process showing that some of the "rules" are just statistical necessities; and established that listeners can determine the genre, style and mood of a piece of music—something that takes hours of score analysis—from the first three seconds (12).



▲ **Figure 2.** An fMRI from the lab of Petr Janata at UC Davis, showing response to familiar music, salient memories, and enjoyable music.

credit: Katie Banks

Music, Language and the Brain

In other laboratories, experiments with music give insight into the nature of the mind. As Huron points out, the opportunity to do this kind of research is fast disappearing with the spread of Western music around the world: we can't say anything about effect on the mind from old recordings, and we can't do cross-cultural experiments to establish brain universals when Western music itself has become universal (4, 8).

"The opportunity to do this kind of research is fast disappearing with the spread of Western music around the world"

But within this limited scope, researchers are gaining a window into the mind and its evolution through its processing of music. We know that there are differences in musician's brains compared to the general population: early musical training confers benefits in non-musical domains, like executive functioning and attention, as well as auditory abilities like attending to one conversation in a noisy environment (the "cocktail-party problem"). One possible explanation is the precision processing of pitch and rhythm required by music, compared to speech—which could argue that music is just like any other kind of highly specialized and exacting training in how it rewires our plastic brain (6).

More striking are the findings by Krumhansl and others that non-musicians also organize sound into discrete, functional pitch categories: even those who don't know what the words mean expect the tonic to follow the dominant (5). Musicians, further, have their sonic worlds reorganized into specifically musical ones: they have trouble conceiving of a sounded tone as anything other than the tonic pitch, and the ebb and flow of complex auditory stimuli is reduced into easier categories. Brain retraining is one piece of the intricate link between music and language, wherein musicians attend more to subtle meanings in speech contours and show gains in language acquisition—hypothesized to come from the organization into abstract sound categories with syntactic relations that both music and language processing require (9). So far the evidence shows that music and language share some processing circuitry, and that even things that should be specifically musical—like the processing of tonality—is involved in speech processing (15). But many research programs are still preliminary, and much teasing out of different effects remains to be done.

Music and Biological Evolution

Beyond functional brain imaging studies and cognitive models, some are beginning to investigate the evolution of the human music capacity and

▲ **Figure 3.** Much has been said about ancient art through the cave paintings at Lascaux, like these in the Hall of Bulls. Some day soon, we may know more about what kind of music was produced in these caves thousands of years ago.

credit: http://lascaux.culture.fr

the role of music across evolutionary history. Be warned: research in this area is marked by heated controversy and a glut of speculation alongside solid empirical studies, and basic philosophical and methodological issues abound. But there is exciting work being done to close this speculative gap, involving activities related to music and language in non-human animals and even "archaeological acoustics." In the Carey psychology lab here at Harvard, some graduate students study the apparent ability of certain songbirds to move to a beat (14).

The research of Harvard affiliate Irene Pepperberg, famous for the "Alex studies" of linguistic and cognitive abilities in parrots, lets us test evolutionary hypotheses rigorously through cross-species studies (11). And across the pond at the University of Cambridge's Music and Science center, director Ian Cross is adapting acoustical methods developed for concert halls in the last two hundred years to archaeological studies of sites thousands of years old (2). In the future, we may be able to say much more about what social functions certain ancient spaces were used for based on these methods.

What's It All For?

The study of music and mind is young, as are empirical musicological studies. Many papers and books in these fields are devoted to foundational issues of method or purpose. So what can come of this work? Already, it has practical clinical and musical significance. Studies of congenital speech and music deficits in Isabelle Peretz's lab in Montreal suggest effective music therapy approaches to helping stroke victims and Alzheimer's patients (3, 7). Bob Slevc at the University of Maryland relates musical ability to second language acquisition, with implications for how we teach children (16). And our computer models of instruments and brains have broad applications in composition: spectral composing based on subtle shifts in timbre, "laptop orchestras" at Princeton and Stanford, and compositions made by artificial intelligence systems that mimic Bach or Palestrina. At Stanford's Center for Computer Research in Music and Acoustics, statisticians and cognitive scientists work alongside composers and musicologists—and this collaboration is the norm at centers across the country. Research like this has a short history, but its future is promising—and its methods and programs have inspired other collaborative projects bridging sciences and the humanities. H

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