

maladies and serves as a caution for appropriate use of genetic testing and therapy.

In the final chapter of the book, Dr. Berger examines the ethics of gene therapy, a realm that has only begun to be explored. The possibilities of gene therapy will only increase as technology advances. Gene therapy raises many questions because its effects are passed down, unlike the effects of somatic cell therapy. Berger asks if it is morally acceptable to make a decision that will continue to affect one's heirs for an untold number of generations. Dr. Berger also addresses the difference between positive gene therapy (enhancing a fetus' height or intelligence) and negative gene therapy (correcting a malady.) After examining the issues relating to gene therapy, the authors conclude that too many potential problems exist at this point to recommend lifting the moratorium on its use.

Overall, the authors of this book do an excellent job of examining current moral questions relating to genetics and evaluating the correct actions to take in difficult situations. While both moral theory and the language of genetics can be intimidating to a reader untrained in either discipline, the authors illuminate the issues and conclusions they reach in a straightforward way. Anyone considering a career in genetic research or medicine would find this book interesting and informative. However, its importance is not limited to any one segment of the population, as the issues addressed will affect all of us in the future.

Music and the Brain

An Interview with Professor Petr Janata

REBECCA BRUCCOLERI '05

Introduction

Petr Janata is a research assistant professor at Dartmouth College in the Psychological and Brain Sciences Department. He, along with Jeffrey L. Birk, John D. Van Horn, Marc Leman, Barbara Tillmann, and Jamshed J. Bharucha, published an article in the December 13, 2002 issue of *Science* on the mapping of Western tonal structures in the brain. This article received a great deal of media attention for one section suggesting that scientists have found the reason why melodies stay in our minds. I interviewed Professor Janata about his article, his fascination with music, and its relation to psychology.

Background

The foundation of Western music is based on keys in which pitches are arranged in different whole tone and semitone sequences to form major and minor scales. The number of sharps (pitches raised by a semitone) and flats (pitches lowered by a semitone) define the key signature.

For each key signature, there exists a major and minor key. In Western music, there is a pattern known as the 'circle of fifths' that defines the distance between the keys. Using the circle of fifths and the fact that there are major and minor keys associated with each key signature, Professor Janata designed a doughnut shaped torus that reflects these key relationships. The major keys are on the outside of the ring and the corresponding relative minor keys are in the inside of the ring. The distance of the major keys in their placement around the ring is reflective of their distance in Western tonal music. Therefore, the keys that are the least related in Western music are on opposite ends of the torus.

Experimentation

Professor Janata had eight subjects with various amounts of musical training listen to a melody in all twenty-four keys. Functional MRI imaging was used to map their brain activity in order to see if a relationship existed between the physical torus and highlighted regions of the brain. What he found was that similar regions of the brain are highlighted for both the major and minor representations of a key signature and that different regions are highlighted for each key signature (Fig. 1). This reveals that the brain recognizes a difference between the keys.

Interview

Rebecca Bruccoleri: What inspired you to research tonal structures in the brain?

Peter Janata: A couple of things – one, musicians have been fascinated about the relationships between the different keys for centuries, and two, psychologists have been interested in how these tonal structures and keys are represented in the mind and in the physical structure of the brain. One of the things that has motivated neuroscientists over the decades has been looking for how the sensory environment is mapped in the brain. For example, how are the circles of the retina mapped in the visual regions of the brain and the representation of pitch height mapped in the basalar membrane in the auditory cortex? The relationship between the music keys requires a higher level of cognitive activity to discern so it is more complex to design methods to see how they are represented in the brain.

R.B.: Did you use equal temperament where all the keys have the same whole tone and semitone relationships?

P.J.: Yes, this was all done with equal temperament.

R.B.: There are some that say the real difference in the keys was lost with the coming of equal temperament since a sharp is now the same as a flat. Your research seems to prove that there is still a difference between the keys. Is this true?

P.J.: Yes, well that is an intriguing question because on the one hand, there is the issue of equal temperament in which the major and minor keys still have the same whole

tone-semitone relationship but have their centers on different pitches. If there was absolute pitch recognition, which is implied by a map of keys, melodies should not be discernable when they are moved from one key to another. In reality, the melodies are recognizable in different keys. My research showed that the brain is activated in different regions as you move through the keys, meaning the brain recognizes different keys, but there is little evidence to show the brain recognizes absolute pitches. For example, we have not observed a region that is consistently activated when you play a F sharp minor chord. Thus melodies are discernable by their relative representation, i.e. the different intervals they contain.

R.B.: Do you think your research shows that expectations we have for music in different keys is learned or inherent?

P.J.: This is also a matter of big debate – there isn't any hard evidence on whether tonal structures are innate or learned. I think that the major opinion is that they are learned. In general, our brains are tuned to different patterns in our environment so we learn over time how to make sense of our environment. So, my assumption is that this is largely learned. However, the question still remains about the natural consonance of intervals such as the fifth or the octave.

R.B.: What do you think are the implications of your research? For example, is the torus that you described in your article also highlighted during other tasks such as solving a math problem, a science problem, or translating another language? Did you find any links between musical acuity and other tasks?

P.J.: There is a lot of controversy over the validity of those connections. I just recently went to a conference in New York along with Francis Rauscher. She has very compelling evidence that students with training do show more skill in certain tasks than those without training. It is not a generalized increase in intelligence, but there certainly are particular tasks that kids score better on if they have gone through musical training.

R.B.: Concerning yourself, do you play an instrument?

P.J.: Very amateurishly piano. It's hard to answer that because there a lot of categories of piano skills, but I make a lot of mistakes.

R.B.: Also along the lines of the future implications of your research: what do you think of the public response to your research? I know that many newspapers have quoted from it and that the Dartmouth College News webpage currently opens with "Melodies in your mind."

P.J.: Yes, that's been an interesting lesson in working with the press. The research was about mapping the torus, which I find personally exciting by itself. When I was talking with a Dartmouth College News science writer, she was trying to get at the popular hooks to all of this. So one observation we made was that the area that was most consistently correlated with this torus across all the subjects

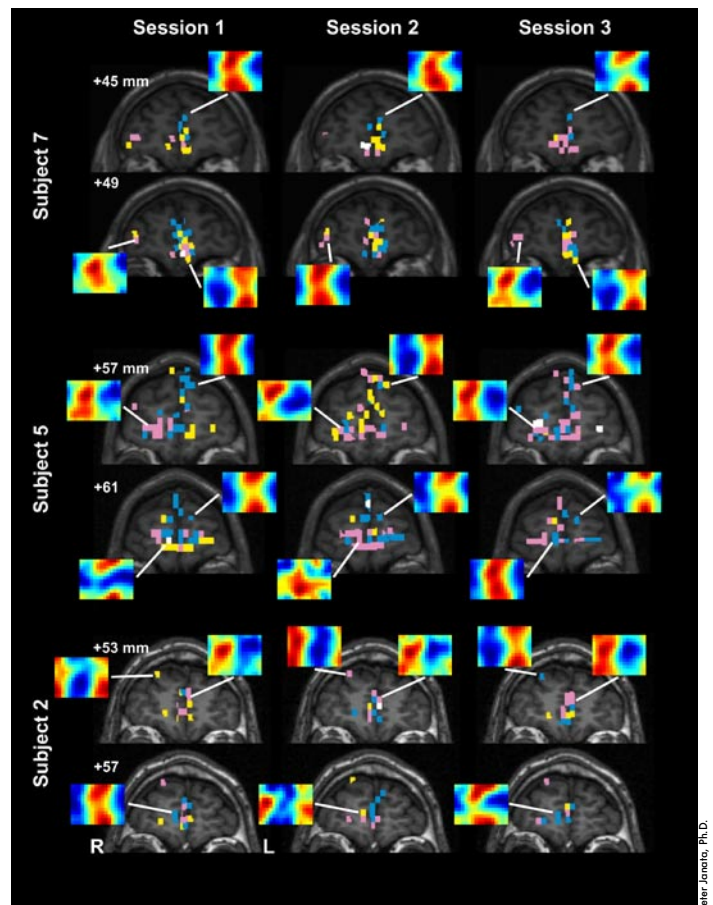


Fig. 1 MRI, mapping of brain activity

that participated was the part of the brain referred to as the rostromedial prefrontal cortex. This is a general region which other people have written about and is involved with the processing of emotional information and cognitive information. This general area is quite active during spontaneous thought or self-reflecting thought so that led to the hypothesis that this region might be responsible for how melodies stay in your mind. In the press release that Dartmouth College put out, it starts out with something like "scientists may be one step closer to understanding why certain melodies are stuck in your head." The key phrase is "may be one step closer," which does not mean that the research proved this. The week before an article comes out, the journal [*Science*] announces the article to the press. The press has four to five days to write their stories, and then the press embargo lifts. The Dartmouth College press release was posted along with the original article and accompanying perspective article, so most people read that first sentence, took out that hypothetical clause about "melodies in your mind," and assumed it was now fact. Everyone wants to know why melodies get stuck in your brain. In radio interviews, I spent most of the time doing damage control and explaining the truth behind my research, though I hope someone can actually answer the question of why melodies stick in your mind.

In the future, Petr Janata would like to write a paper on the psychology of the dominant seventh.