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Music and the Brain

Course Guidebook

Professor Aniruddh D. Patel
Tufts University

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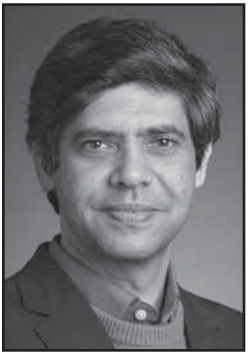
THE GREAT COURSES
Corporate Headquarters
4840 Westfields Boulevard, Suite 500
Chantilly, Virginia 20151-2299
Phone: 1-800-832-2412
Fax: 703-378-3819
www.thegreatcourses.com



Aniruddh D. Patel, Ph.D.
Professor of Psychology
Tufts University

Professor Aniruddh D. Patel is a Professor of Psychology at Tufts University. After attending the University of Virginia as a Jefferson Scholar, he received his Ph.D. in Organismic and Evolutionary Biology from Harvard University, where he studied with Edward O. Wilson and Evan Balaban. His research focuses on the cognitive neuroscience of music.

Prior to arriving at Tufts, Professor Patel was the Esther J. Burnham Senior Fellow at The Neurosciences Institute, a scientific research organization founded by the late Nobel laureate Gerald M. Edelman. Professor Patel's major contributions have included research on music-language relations, the processing of musical rhythm, cross-species comparisons, and relations between musical training and neural plasticity.

Professor Patel is the author of *Music, Language, and the Brain*, which won a Deems Taylor Award from the American Society of Composers, Authors and Publishers in 2008. In 2009, he received the Music Has Power Award from the Institute for Music and Neurologic Function in New York City.

Between 2009 and 2011, Professor Patel served as President of the Society for Music Perception and Cognition. He is active in education and outreach, having given more than 70 scientific lectures and colloquia and more than 20 educational and popular talks. Professor Patel's research has been reported in such publications as *The New York Times*, *New Scientist*, and *Discover* magazine and on National Public Radio. He has appeared in science documentaries, including *The Music Instinct*, which aired on PBS. ■

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Music and the Brain

Scope:

This course will introduce you to the new field of music and the brain. Interest in music and the mind is more than 20 centuries old, but most of what we know about music and the brain today was discovered in just the last 20 years.

In the first lecture of this course, you will learn about how cultural and neuroscientific approaches to music can coexist and about how music perception engages brain regions far outside of the auditory cortex. The next two lectures focus on evolutionary studies of music. You will learn about different theories of the adaptive role that musical behavior played in human evolution (including Charles Darwin's theory) as well as theories that argue that music is a purely cultural invention, which arose without any impetus from biology. Theoretical debates about music and adaptation continue today, but in recent years, a new approach has emerged. This approach uses empirical research, including behavioral experiments with humans and other species, to test ideas about the evolutionary history of music.

In the next two lectures, you will learn about the relationship between music and emotion. You will learn about the different ways in which music can express emotion, including by using acoustic cues shared with emotional speech. You also will learn about several different ways in which music can evoke emotion in listeners' brains and how these relate to music's ability to communicate cross-culturally.

The following lecture examines two fundamental building blocks of music—pitch and timbre—and explains how the perception of even single musical sounds (or very short musical excerpts) involves complex mental processing. Next, you will learn how combinations of pitches give rise to the perception of consonance and dissonance and how musical scales and keys are organized, physically and psychologically. You will discover how implicit learning gives rise to powerful expectations that shape your perception of music and your emotional responses to music.

The next two lectures focus on musical rhythm. You will learn that there is much more to musical rhythm than the beat. You also will learn that beat processing is surprisingly complex from the standpoint of brain science. In the following lecture, you will learn how the brains of musicians differ from those of nonmusicians and about the role of experience (versus innate factors) in shaping these differences. In the next lecture, you will learn about cognitive benefits associated with musical training and how researchers tease apart whether these are caused by musical training or merely correlated with musical ability. The next two lectures shift to explore how music cognition develops in normal individuals and how it goes awry in individuals with neurological music perception disorders.

In the following two lectures, you will learn about the relationship between music and neural rehabilitation. These lectures focus on people with a variety of medical conditions, from newborns in neonatal intensive care units to older adults with strokes or Parkinson's disease who suffer from problems with language or movement. You will learn how both listening to music and making music can have measurable biological impacts on medical patients.

In the penultimate lecture, you will learn how human song compares to the songs of other animals, including birds and whales. The last lecture will return to evolutionary questions from the standpoint of cognitive neuroscience and will explore the biological significance of music.

At the end of this course, you will be able to appreciate how much science has learned about music and the brain in the past 20 years, and you will have a solid foundation for understanding the future discoveries that lie ahead in this young field of research. ■

Music, Language, and Emotional Expression

Lecture 4

The focus of this lecture is on the emotions that are expressed by music—those emotional qualities that listeners perceive in a musical piece, whether or not they have an emotional response. How does music express different emotions? For example, what makes a piece of music sound sad? Or joyful? Or angry? By focusing on how music expresses emotion, we can explore the idea that music and language processing have significant overlap in the mind.

The Study of How Music Expresses Emotion

- The study of how music expresses emotion brings up two themes. The first is the concept of multiple simultaneous mechanisms. Much of the psychological richness of music comes from the fact that it simultaneously activates multiple distinct processing mechanisms, some of which rely on brain regions well outside of traditional auditory processing areas.

- The second theme is the connections between music processing and language processing—the relations between the processing of purely instrumental music (music without words) and the processing of ordinary, day-to-day spoken language. There must be some sharing of brain processes by music and spoken language: They both use the auditory channel for communication. The question is how much overlap there is in the mental foundations of these two abilities.

- If there are important shared cognitive mechanisms, then these mechanisms are likely to be fundamental to how humans communicate with each other, and we have two pathways for exploring them: a path through music and a path through language. In addition, if music and language have significant cognitive overlap, this means that we might be able to use music training to impact language processing.

The Expression of Emotion in Prosody and Music

- Like music, speech is another sound pattern than can be used to express emotions. When we speak, we don't just convey words and phrases; we convey attitudes and emotions by the way we say those words and phrases. The pace and loudness of our voice, the way pitch moves up and down, the rhythm of our syllables, and the way we articulate our speech sounds all work together to express an emotional tone.

- These elements of language are called speech prosody. As listeners, we're sensitive to the emotions expressed by speech prosody: We know when someone sounds happy or angry from the way that he or she talks, not just from the words he or she says. If we can see the person, we also get cues to emotion from his or her facial expressions and gestures, but we can perceive emotions from just speech prosody, such as when we are talking on a phone. And we can perceive emotions in nonspeech vocal sounds, such as laughter or crying.

- The kinds of emotions that are most clearly expressed by speech prosody are what psychologists call primary emotions or basic emotions. These are thought to be ancient and universal human emotions, such as happiness, sadness, anger, and fear, which have a strong biological basis and have analogs in the emotions of other animals.

We can perceive emotions just from the way a person talks; we don't necessarily need to see the person.

- These basic emotions can be contrasted with secondary, or more complex, emotions that depend more on culture and learning, such as jealousy or guilt. It's more difficult to express

these secondary emotions by the way you say something—conveying them depends more on the actual words you say or actions you make.

- We believe that the basic emotions have a long evolutionary history. Darwin argued that we share basic emotions with other species, and subsequent biologists have supported this idea with research that looks at similarities in the neuroanatomy and neurochemistry of basic emotions in different mammalian species.

- So, when we express basic emotions in speech, we're likely tapping into ancient emotional circuitry with our evolutionarily modern language system. One line of evidence that supports this idea is that the way basic emotions are expressed through speech is much more consistent across languages than many other aspects of language.

- In the language sciences, there has been a lot of interest in how different emotions are expressed through speech. Researchers have done detailed sound analysis of voices expressing different basic emotions, such as happiness or sadness, and have found some consistent acoustic cues that distinguish these different emotions.

- Happy-sounding speech tends to be relatively fast, with medium to high loudness; has a high average pitch and a wide pitch range, a brighter sound quality, and crisp articulation; and emphasizes upward pitch movements. Sad-sounding speech is slow, quieter, and lower in average pitch with a narrow pitch range, a darker sound quality, and duller articulation, and it emphasizes downward pitch movements.

- In 2003, Patrik Juslin and Petri Laukka published a landmark study that provided strong support for this idea. They reviewed many acoustic studies of emotion expression in speech and music and found a remarkable degree of correspondence in the acoustic cues to basic emotions in the two domains. For example, the same cues that are characteristic of happy- and sad-sounding speech are also seen in music that listeners judge as sounding happy or sad.

- Music can express different shades of a basic emotion, such as sadness, just as a painter can use different shades of a basic color, such as blue. Music also can express different intensities of basic emotions, such as joy, just as a painter can choose the intensity of a particular hue. And music can blend cues to different basic emotions, which allows for more complex emotional expressions than just the basic emotions. By varying the shading, intensity, and blending of basic emotions, music can express emotions that are rich and nuanced and not simply captured by basic labels like "happiness" or "sadness."

By varying the shading, intensity, and blending of basic emotions, music can express emotions that are rich and nuanced and not simply captured by basic labels like "happiness" or "sadness."

- Music goes beyond speech prosody in its ability to convey emotions with sound. Unlike speech prosody, music can simultaneously express a blend of different basic emotions, producing something closer to the complex inner feelings that we have but that we can't express with speech prosody alone.

- Juslin and Laukka suggested that one distinct way that music uses those cues is that it makes them stronger than emotional cues that occur in ordinary speech. For example, happy speech has limits on its tempo and volume and pitch range because of physical limits on the human voice. Musical instruments can go beyond these limits; they can take some of the same cues that make a voice sound joyful and make them stronger.

- Juslin and Laukka suggested that this made instrumental music a kind of superexpressive voice from the standpoint of brain processing—that is, even though a listener consciously knows that a piece of instrumental music is not a human voice, at some level of brain processing, the sound is being analyzed as a voice, but a voice with powers of emotional expression that far outstrip anything a human voice could do.

- This idea could help explain why we're so attracted to the sounds of musical instruments: This attraction could be based on inborn attraction to the sound of human voices and our natural tendency to be sensitive to the emotional qualities of those voices.

The Connection between Vocal and Musical Affect Expression

- An interesting line of research that is consistent with the idea that we perceive emotions in music and in voices using similar brain mechanisms comes from cross-cultural studies of the perception of emotion in music.

- Musical traditions vary enormously around the world, and if the way emotion was expressed also varied enormously, then you would expect that people from one culture would not be able to accurately perceive emotions in the music of another culture.

- In 1999, Laure Lee Balkwill and William Forde Thompson published a study that showed that people can guess the basic emotion conveyed by culturally unfamiliar music, although they are not as good as cultural insiders. Cues that can be related to speech prosody seem to play a role, which makes sense, because voices convey basic emotions in similar ways across cultures.

- The most direct evidence for overlap in the brain pathways that perceive emotion in music and in voices comes from brain imaging. An fMRI study published by Jorge Armony and colleagues found that when people listen to either music or voices that express the emotion of fear, a similar cluster of brain regions is activated, which includes the left amygdala, a deep-brain structure that's known to be involved in processing threat-related stimuli.

- Individuals showed a correlation in how strongly their amygdalas responded to expressions of fear in music and in the voice. Most likely, none of these listeners would consciously confuse the sound of the music with the sound of a human voice, but parts of their brain are subconsciously "confusing" the two sounds when it comes to analyzing their emotional qualities.

- Furthermore, researchers found that children who had studied piano for a year were as good at perceiving emotions in spoken voices as children who had studied drama for a year (and both were better than children who had no special training). Music training enhanced an aspect of language processing that hadn't been directly trained.

Other Ways Music Can Express Emotion

- In 1980, Stephen Davies and Peter Kivy suggested that music's emotional expressiveness is based on a perceived resemblance between how music moves and nonverbal human expressive behavior. This theory, which is called the contour theory of musical expressiveness, emphasizes how we tend to perceive emotion in things that resemble nonverbal human expressive behavior, even if those things are inanimate.

Humans' interest in the emotions of others leads us to anthropomorphize inanimate objects, such as the "weeping willow."

- Stephen Davies suggests that it's our strong human interest in the emotions of others that leads us to read expressiveness in inanimate objects that just happen to resemble the way human bodies express emotions, such as "weeping willow" trees.

- Two ways that music expresses emotions—with acoustic cues that resemble speech prosody and through resemblances to human nonverbal expressive behavior—are the most likely to cut across cultural boundaries, because the way voices and bodies express emotion has a deep biological basis that cuts across cultures. But there are culture-specific aspects to how music expresses emotion that aren't obvious to cultural outsiders.

- Music can express emotion through the ebb and flow of tension in music. All around the world, music is structured in ways such that at certain points listeners perceive a sense of tension, a sense that the music must continue before coming to a resting point.

- The ebb and flow of tension is central to music all around the world. We can think of it as a kind of emotional expression that's very dynamic: It unfolds in time, giving music a kind of emotional narrative that can reflect the way our own emotions unfold over the course of a day, although music can make this happen over just a few minutes.

- Different musical traditions create tension in different ways. In Western European music, harmony plays a big role, but not all musical traditions have harmonic structure. Other traditions might use greater or fewer degrees of acoustic consonance or dissonance, or melodic complexity, or other features to create tension and resolution. This means that a cultural outsider is much less likely to pick up on these cues to emotion, because they are more culture-specific.

- Finally, there are conventional associations between aspects of musical structure and expressions of emotion. For example, the philosopher Peter Kivy has suggested that in Western music we have come to perceive minor keys as expressing darker moods, such as sadness or seriousness, purely by conventional associations, not because those keys intrinsically reflect dark moods.

- Conventional associations can be psychologically powerful and shared by many listeners. Pioneering work on how music expresses emotion in the 1930s by the psychologist Kate Hevner included experiments in which the same piece was played in a major or minor key, while everything else about the piece was kept constant.

- When people rated the emotions expressed by the different versions, there was a lot of consistency in rating the minor-key version as more somber, without any feeling of conscious effort. This could lead to the sense that this is an unlearned, instinctive response, but that's an illusion. Several studies have shown that children seem to learn that the minor key expresses sadness.

Suggested Reading

Balkwill and Thompson, "A Cross-Cultural Investigation of the Perception of Emotion in Music."

Juslin and Laukka, "Communication of Emotions in Vocal Expression and Music Performance."

Questions to Consider

1. What is the conceptual difference between music's ability to express emotion versus induce emotion?

2. What are some similarities in the way that emotion is expressed in music and speech?