Photo Quan Trinh and William Niebling

New Horizons in Music Cognition

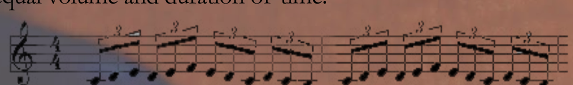
By Michael Alpert

The field of music cognition has exploded in recent years. Cognitive scientists are currently analyzing nearly every aspect of musical performance and listeners' response mechanisms. How does a listener process a melody's beat? How can performers utilize expressive timing to make their own unique mark on a piece of music? Two current studies at Yale are investigating the mechanism by which a listener and a performer process the timing of each note's placement in a particular piece of music.

I Got Rhythm—So Do You

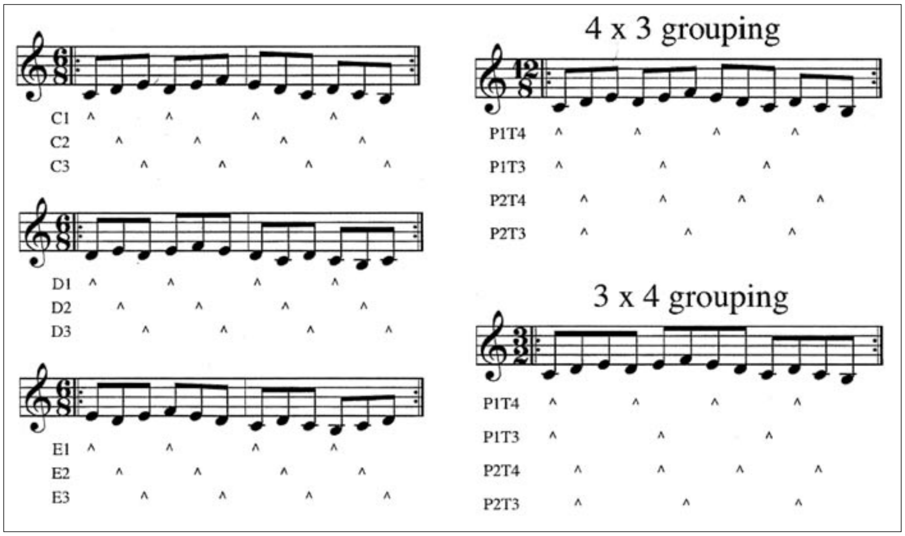
Any song's melody can be broken down into two different components: pitch and rhythm. Most pieces of Western music have a clear beat or underlying pulse on which the rhythmic structure of the melody is based. In recent years, cognitive scientists have begun to focus on the process through which we perceive this underlying pulse.

Bruno Repp, a cognitive scientist at the Haskins Laboratory in New Haven, CT, entered the field of music and cognition after years of studying linguistics and speech. In many works of music, composers and artists use regularly timed accents, drumbeats, or other kinds of musical devices to mark the pulse. Repp postulates that there is a mechanism in the brain responsible for imposing a regular beat onto a piece of music, regardless of whether the pulse is marked or not. In order to test the hypothesis that the beat is processed as an independent entity, Repp designed the following twelve-note sequence in which all notes were generated at an equal volume and duration of time:



Repp asked musicians familiar with Western-style notation to tap on the first note of each triplet grouping. He then increased the speed at which the sequence was played until the subjects could no longer perform the task. After testing all three versions of the sequence, Repp found that tapping on the first note in each triplet sequence was easier for subjects, regardless of whether it started on the C, the D, or the E. Repp also rearranged the notation of the piece from 12/8 to 3/2 and asked his subjects first to tap every fourth note and then to tap every third note as before. The subjects tapped on every third note at a much slower rate than they had when given the original notation.

Repp explains these findings with the principle of covert action. When a listener hears a piece of music, the brain performs a constant process that imposes a beat onto the music. When the beat is strong and lively, people often express this covert action through an overt one, such as clapping, tapping, stomping, or dancing to the pulse. A disparity forms between the subject's covert and overt actions when the subject is asked to tap on a note other than the perceived downbeat, resulting in a slowing down of the maximum tapping speed. Neuroimaging studies conducted by other research groups have correlated increased brain activity with the expectation of a downbeat, further supporting Repp's theory of a regulatory beat mechanism in the brain.



(Left) Repp asked his subjects to tap in synchrony with the note designated by the "^" symbol. In the first set of variations, he altered both the starting note of the sequence and the location of the "^" symbol among the three different notes in the triplet grouping. The maximum speed at which subjects could tap C1, D1, and E1 was much faster than for the other variations. In all three of these variations, the subject was required to tap on the downbeat. (Right) In the second set of variations, the original melody was organized into the 4x3 and 3x4 groupings pictured. The maximum speed at which the subjects could tap the P1T4 when presented with the 3x4 grouping was faster than when presented with the 4x3 notation of the same melody. In addition, the maximum speed at which they could tap P1T3 was faster when presented with the 4x3 grouping than with the 3x4 notation. These results indicate a systematic mental organization of the melody into discrete units based on the musical notation presented to the subject.

Cognition at the Keyboard

As listeners can interpret a particular melody in a number of different ways, the performer is responsible for deciphering how the composer intended an audience to hear a given piece of music. Naturally, each performer has a slightly different take on how a piece of music should sound. Repp has collaborated with Günther Knoblich, a cognitive scientist at Rutgers University, to analyze the qualities that musicians instill into a performance, allowing them to recognize their own renditions of musical compositions at a level above chance.

In this study, Repp enlisted twelve pianists at Yale. Each subject was given only a few minutes of preparation time and then asked to perform a series of relatively unfamiliar pieces of music by different composers. Several months later, the pianists returned to evaluate the performances of all twelve subjects, rating on a scale of one to five how close each was to their own performance. The subjects were correct 50% of the time, well above the 8% expected by pure chance.

After establishing the fact that self-recognition exists, the researchers then began to strip away different traits from the performances that could have allowed the performers to distinguish their own playing from the other eleven recordings. Interestingly, the subjects recognized themselves equally well, even after all the performances were adjusted to the same speed and overall loudness level. After all dynamic nuances (variations in volume within a performance) were removed to leave only articulation and expressive timing as distinguishing features, the subjects performed slightly worse but still well above random chance.

Monkey See, Monkey Do

Repp and Knoblich explain their subjects' abilities to self-distinguish through the processing mechanism known as "mirror nuance." While cognitive scientists have studied this mechanism for decades, they have never applied it to exploring how an individual perceives his or her own musical performance.

The "mirror nuance" is a neural response that occurs upon observing the performance of a particular action. When a primate sees a researcher perform a task such as placing a raisin in his or her own mouth, the same parts of the primate's brain are activated as when it eats the raisin itself, with the exception of the region responsible for motor control. Giacomo Rizzolatti, Italian professor of human physiology at the Universita Degli Studi di Parma, has subsequently studied this same ability in humans using fMRI techniques. Humans, he discovered, also exhibit simulation of the brain activation pattern caused by a particular action when they merely observe or imagine the action being performed.

Pianists listening to a recording will simultaneously simulate playing the piece themselves. When pianists then listen to self-recordings, the simulated performance they had internalized mentally matches up closely with the actual recorded performance. This resonance between the simulated and actual performance results in increased neural activity, which allows pianists to identify the performer (themselves) correctly. According to this study, articulation and expressive timing in a performance are primarily responsible for this resonance.

A Wide Open Field

The research described thus far represents only a small sample of the vast amount of new information about music and cognition acquired in recent years. For example, Daniel J. Levitin, associate professor of psychology at McGill University, postulates that the overarching structure in a piece of music is processed by the same brain region as that which is involved in evaluating the grammatical structure of a sentence. Bradley W. Vines, a protégé of Levitin, focuses his research on the use of body language in a performance to convey emotion and phrasing to an audience. Despite the vast array of topics in the field, these cognitive scientists are united in their respect and appreciation for music as an expressive, powerful form of non-verbal communication. Y

About the Author

MICHAEL ALPERT is a junior in Jonathan Edwards College majoring in East Asian languages and literature. He performs regularly with the Yale Symphony Orchestra on the French horn and got his first exposure to the field of music cognition as a guinea pig in Dr. Repp's self-recognition study for pianists.

Acknowledgement

The author thanks Dr. Bruno Repp for his assistance in this article.