Chapter 13

**MUSIC PERCEPTION**

Music is sound created in ordered and meaningful patterns. Pitch, dynamics, rhythm, and timbre are the basic building blocks of music. Musicians combine these building blocks in infinite ways to create music of all types. Pitch is the subjective experience of sound that is most closely associated with frequency and is related to the experience of whether a sound is high or low. The octave is the interval between one note and a note with either double or half the frequency of that note. Notes that are one octave apart are of the same chroma, which is the subjective quality of a pitch. In Western music, there are 12 semitones (12 equal intervals) within each octave. Western music also uses an equal-temperament scale, meaning that every adjacent note has an identical frequency ratio. Harmony occurs when two or more notes are played together and sound pleasant. When two or more notes are played together, consonance is the perception of harmony, whereas dissonance is the perception of disharmony. Dynamics refers to the relative loudness of music and how loudness changes across a composition. Rhythm is the temporal patterning of music, including tempo (speed of music), meter (temporal pattern of sound across time), and beat (spaced pulses that indicate if a piece is fast or slow). Timbre is the complex sound created by harmonics. Most music starts with a melody is a rhythmically organized sequence of notes, which are perceived as a single musical unit. A scale is a set of ordered notes starting at one note and ending at the same note one octave higher. Key refers to the tonic note that gives a subjective sense of arrival and rest in a musical piece. The gestalt principles of proximity, similarity, closure, and good continuation are applied to melody processing over time.

As a result of differences in interest, culture, and exposure to music, there are individual differences in the regions responsible for music perception. Nevertheless, at least five commonalities in music perception are seen across individuals. First, music perception usually causes greater activation in the right temporal lobe than the left temporal. Second, the right secondary auditory cortex is important for pitch perception. Third, rhythm appears to be processed in areas of A1, primarily the right belt and parabelt regions. Fourth, visual areas are activated when listening to music. Fifth, musical training results in different organization of the motor cortex, in response to the demands of the complex motor movements necessary to play most instruments. Synesthesia is a condition in which a stimulus in one modality consistently triggers a response in another modality. People with color-music synesthesia have experiences of colors when particular pitches, notes, and chords are heard, due to greater activation of the tract connecting the frontal lobes and the auditory cortex. Amusia is a condition in which brain damage interferes with music perception, but other auditory processing remains intact. As a result of differences in interest, culture, and exposure to music, there are individual differences in the regions responsible for music perception. Several musical illusions exist, which occur when our music perceptions are tricked into perceiving patterns that are not present.

Introduction

* Music is found all over the world and, if heard, it is instantly recognized as music.
* Music also has a long history. Reconstructions of flutes dating back 35,000 years ago show that the notes representing octave equivalence were present.
* Though music is essentially universally recognized, it is difficult to come up with a definition of music that satisfies all of its boundary conditions.
* Nevertheless, **music** could be defined as ordered sound made and perceived by humans, created in meaningful patterns.

The Acoustics of Music

Pitch, Chroma, and the Octave

* Recall that **pitch** is the subjective experience of sound that is most closely associated with frequency.
  + Though humans can hear the range of frequencies from 20 to 20,000 Hz, the range used in music is more restricted, with a range of only up to about 5,000 Hz.
    - A piano has its lowest note tuned at 27.5 H and its highest note tuned at 4,186 Hz.
    - Humans have the capacity to sing between 75 Hz and 1,300 Hz.
  + Although the fundamental frequency of musical notes seldom exceeds 5,000 Hz, harmonics typically range higher than this.
    - This means that in addition to the pitch that is heard, there are other sounds present at higher frequencies, which contribute to the experience of timbre.
  + The piccolo has the highest notes of any instrument used in Western music.
* The **octave** is the interval between one note and a note with either double the frequency or half the frequency of that note.
  + A frequency of 200 Hz has octaves of 100 Hz below it and 400 Hz above it.
  + Psychologically, we hear similarities between these halved and doubled frequencies.
  + In musical terms, they are referred to as the same note but at different octaves.
* Notes that are one octave apart are said to be of the same **chroma**.
  + For example, each C note on a piano shares a feature of sound in common with other C’s, but not with other notes.
  + The similarity of chroma from one octave to the next can be represented by a pitch helix.
* “Sharps” and “flats” are keys at frequencies approximately halfway between the frequencies of the major chromas of notes (C, D, E, F, G, A, B).
  + When the sharps and flats are added to the musical hierarchy, there are 12 notes in an octave, as we ascend from one note to the same note an octave higher.
  + Each adjacent note is called a **semitone.**
  + Almost all Western instruments allow musicians to play all 12 notes of the octave.
* In Western musical tradition, an **equal-temperament scale** is used, meaning that every adjacent note has an identical frequency ratio.
  + The absolute difference between adjacent notes increases as one gets higher in frequency, but the ratio matters for perception.
  + One advantage of the equal-temperament system is that any melody can be played starting on any particular note.
* In most Western music, the differences in frequency between each note are well established and do not vary.
* Traditional Chinese music uses a different scale system.
  + Instead of the diatonic (eight-note) scale used in Western music, Chinese music uses a pentatonic (five-note) scale
  + Also, the notes are not tuned according to an equal-temperament system.

Consonance and Dissonance

* **Harmony** refers to the pleasant sound that results when two or more notes are played and fit together.
* **Consonance** refers to the perception of pleasantness or harmony when two or more notes are played and do not fit together.
* **Dissonance** refers to the perception of unpleasantness or disharmony when two or more notes are played.
* When more than two notes are played at the same time, the result is called a chord.
* Musical context and culture play a role in our perception of consonance and dissonance.

Dynamics and Rhythm

* **Dynamics** refers to the relative loudness and how loudness changes across a composition.
  + Changing from loud to soft may be important in transmitting the meaning and emotion in a piece of music.
* **Rhythm** refers to the temporal patterning of the music, including the tempo, beat, and meter.
  + **Tempo** refers to the speed of a piece of music.
  + **Meter** refers to the temporal pattern of sound across time, which usually repeats itself across the piece.
  + **Beat** refers to spaced pulses that indicate if a piece is fast or slow.
  + Meter reflects how many beats occur per musical measure and beat reflects the notes that are emphasized.

Timbre

* **Timbre** refers to the complex sound created by harmonics.
* Depending on context, specific timbres of different instruments will convey particular meanings or emotions.
* Given that the harmonics of musical notes often exceed 5,000 Hz, recording equipment should be able to record frequencies in excess of 5,000 Hz in order to capture the full timbre of a composition.
* Timbre is also important for distinguishing well-made and poorly made instruments.
* **Attack** refers to the beginning buildup of a note.
  + Timbre is affected by how quickly an instrument expresses all of its frequencies and if there are any differences in the onset of harmonics.
* **Decay** refers to how long the fundamental frequency and harmonic remain at their peak loudness until they begin to disappear.
* Pitch, dynamics, rhythm, and timbre are the basic building blocks of music. Musicians combine these building blocks in infinite ways to create music of all types.

Melody

* **Melody** is a rhythmically organized sequence of notes, which are perceived as a single musical unit or idea.
* Most music starts with a melody.

Scales and Keys and Their Relation to Melody

* + A **scale** is a set of ordered notes starting at one note and ending at the same note one octave higher.
  + In Western music, major scales refer to sequences of notes with the following pattern of semitones: 2, 2, 1, 2, 2, 2, 1.
  + In contrast, chromatic scales refer to notes in which every step is one semitone.
  + Minor scales have different sequences of semitones as one moves from one octave to the next.
  + Every melody is played in a particular key, which refers to the main scale pattern. **Key** refers to the tonic note (e.g., C in a C major or minor scale) that gives a subjective sense of arrival and rest in a musical piece.
  + **Transposition** refers to the ability of a melody to have more than one version that start on different notes but contain the same intervals or sequence of changes in notes.

Gestalt Principles of Melody

* + Given the importance of the relation among notes rather than absolute pitch and given that perception of melody is qualitatively different than the perception of a string of pitches, melody perception lends itself to the use of gestalt principles.
  + The gestalt principles of proximity, similarity, closure, and good continuation are applied to melody processing over time.
  + *Proximity* refers to the elements being close together in pitch, time, or space.
  + *Similarity* creates seamless perceptions of melody even when the melody crosses from one voice or instrument to another.
  + *Closure* means that a melody should end on the tonic note of any particular scale or another note implied by the progression of the melody.

The Neuroscience of Music

The Neuroanatomy of Music

* As a result of differences in interest, culture, and exposure to music, there are individual differences in the regions responsible for music perception.
* Nevertheless, some generalizations about how music perception occurs in the brain can be made.
  + Music perception usually causes greater activation in the right temporal lobe than the left temporal lobe.
  + The right secondary auditory cortex.is important for pitch perception. However, the greater the musical training, the more left-hemisphere involvement one sees in music perception.
  + Rhythm appears to be processed in areas of A1, primarily the right belt and parabelt regions. People producing rhythm have more prominent activity in the left prefrontal cortex, left parietal cortex, and the cerebellum.
  + Visual areas are activated when listening to music, perhaps because listening to music invokes thoughts that invoke visual images.
* Musical training results in differences in the networks for musical perception.
  + The organization of the motor cortex changes in response to the demands of the complex motor movements need to play many instruments.
  + Musically trained individuals recruit fewer neurons to do an easy manual task relative to controls.

Synesthesia

* **Synesthesia** is a condition in which a stimulus in one modality consistently triggers a response in another modality.
* **Color-music synesthesia** occurs when particular pitches, notes, or chords elicit experiences of particular visual colors.
* People with synesthesia tend to have stronger connections between one sensory area and another. In particular, people with color-music synesthesia show greater activation of the connection between the frontal lobes and the auditory cortex.

The Neuropsychology of Music

* **Amusia** is a condition in which brain damage interferes with music perception, but does not interfere with other auditory processing. Usually acquired, there is also a form of **congenital amusia.**
* The critical deficit is an impaired ability to discriminate pitches.

Learning, Culture, and Music Perception

Music and Language

* An a result of differences in interest, culture, and exposure to music, there are individual differences in the regions responsible for music perception.
* Music neuroscientist Aniruddh Patel asserts that language and music have much in common at the behavioral level.
  + Both are perceptive (listening) and productive (singing, talking) systems in which both perceiving and producing are equally important.
  + Both involve perception of novel and complex sounds that unfold rapidly over time.
  + Both have structure that must be followed in order to make sense to the listener.
  + Meaning of words and notes can vary as a function of context.
  + On a neural level, both use the same basic auditory mechanisms.
* Differences between music and language perception obscure the parallels between music and language.
  + Speech perception is based on the inference of subtle differences in the patterns that produce different vowels and consonants, whereas music focuses on pitch and pitch contrasts.
  + The meaning in music extends beyond what is sung.
  + The neural evidence could be interpreted to suggest language and music differences: language in the left hemisphere and music in the right.

Learning, Culture, and Music Perception

* Western music (including classical, pop, jazz, hip-hop, rap, reggae, rock ‘n’ roll, heavy metal, bluegrass, and country) all share the same scale structure, the same relations among notes within the octave, a common way of notating written music, and a common set of assumptions about what is consonant or dissonant.
* Outside the Western music tradition, music is organized by radically different principles.
  + Indian rag scales have 22 notes within each octave and few of these notes fall exactly at the same frequencies as Western notes.
  + Javanese gamelan music uses different scale systems called slendro, which is a pentatonic scale, and pelog, which is a seven-tone scale. Compared to Western music, the notes are distributed at different octaves relative to the octave of each scale.
  + Musical traditions differ in terms of rhythm as well.
* The relation between music and the experience of emotion may be universal across musical traditions.

***In Depth: Musical Illusions***

* Several musical illusions exist, which occur when our music perceptions are tricked into perceiving patterns that are not present.

Shepard Tones

* In Shepard tones, one hears a scale that sounds like it increases in pitch continually.
* The pitches sound like they are getting continually higher, but in fact, the sound frequencies return back to lower frequencies without our noticing it change from one note to the next.
* The illusion can also be run in reverse, with the perception being that the notes get lower and lower, when they actually do not.

The Octave Illusion

* In the octave illusion, one tone is presented to one ear while another tone, exactly one octave higher or lower, is presented simultaneously to the other ear.
* The next note combination is of the same two notes, but to the opposite ears.
* You should hear the same note, alternating between ears, and another note also alternating between ears.
* However, most people report hearing a single note in the right ear followed by a single note an octave lower in the left ear and then a continuous alternation between the two occurs.
* The illusion is likely due to differences in pitch processing between the left and right auditory cortices.

The Tritone Paradox

* *Tritone* refers to the half octave, or the interval spanning six semitones.
* In the Tritone paradox, each note is an envelope of sound sweeping from one octave to the next, but with a heard pitch equivalent to the lower note.
* The paradox is that some people hear the notes ascending whereas others hear the notes descending.