Auditory Perception - Music

1/27/15

Objectives: Students will listen to various sound samples composed of sounds with and without harmonics to learn about the relationship between . Students will use audio processing software to explore Autotune-style tone correction and discuss how/why the output sounds unnatural or robotic. Students will play instrument (samples) to distinguish between the harmonic profiles of the different instruments.

Concepts:

1. Frequency and amplitude are important but basic elements of sound
2. Normal hearing requires a range of cochlear sensitivity, not just bands
3. Sounds are composed of multiple component frequencies
4. Perceived pitch is based on the particular mix of frequencies heard
5. Instruments sound different because of the harmonics they produce
6. The brain is a pattern-generator/predictor

Setup:

Materials: laptops, headphones/speakers, USB drives, frequency generator iphone app

Teacher Preparation: download Audacity and plug-ins OR update/activate Garage Band, download a frequency generator app, load USB drive with audio files and diagrams

Classroom Preparation: separate tables, dump USB drive contents onto the laptops, get whiteboards and markers

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In the Classroom:

Warm-up Discussion (5-10 minutes):

- *"What kinds of music do you listen to?"* What goes into the sounds that you hear? (vocals, instruments, audio processing)

- *"How do we know what sounds good??"* The brain is a pattern predicting machine - it likes patterns, whether through tones or beats, and it is tickled by slight variations on patterns and themes

Lesson Introduction/Description (10 minutes):

- "Today we will talk more about how our brain perceives sound and music and how different features of sound may influence how we perceive the sound/music."
- *"How do we hear music?"* Review prior knowledge of waves and cochlea (drawing on the main whiteboard, xylophones)
- *"What happens when the ability to hear sound is (partially) lost?"* Get cochlear implants! But… (samples from https://auditoryneuroscience.com/prosthetics/music)
    - First: Play vocoded sample
    - Second: Play normal sample
    - Ask:
        - "Which sounded better, the first or the second sample? What was the difference?" *Cochlear implants do a very poor job at conveying musical pitch.*
        - "What needs to be taken into consideration before making a cochlear implant? What's most important? Speech? Music?"

Hands-on Group Activities (10-15 minutes each):

Part 1: Fundamental Frequencies and Harmonics ("Basic Harmonics" folder) from https://auditoryneuroscience.com/topics/missing-fundamental, https://auditoryneuroscience.com/topics/why-missing-fundamental-stimuli-are-counterintuitive

- *"What is a note?"* a sound with a particular duration and fundamental frequency
- *What is a harmonic?* a multiple (in Hz) of a fundamental frequency (note, pure tone)
- Play the following samples:
    - pure tones sample (or frequency generator app)
    - pure tones PLUS harmonics sample
    - only higher harmonics sample
    - *"Compare the sounds: Do they sound different? Higher or lower?"* (NO!) Look at the respective spectrograms - perceived pitch is more than just the fundamental frequency
- BUT: "The fundamental frequency is obviously important."
- Play the missing fundamental sample

    - *“Compare the sounds: Do they sound different? Higher or lower?”* The B sound is perceived as lower because they are the harmonics of a fundamental frequency that is lower than the A sound
    - ***“The brain is a ‘pattern-generator/predictor’”*** - it fills in the fundamental frequency, even if it is MISSING

Takeaway: Sounds are made up of harmonically related, component frequencies.

Part 2: Harmonics and Timbre in Music

- *“Does a C from a guitar sound the same as a C from an ukulele/saxophone/piano/etc?”*
- Ask the students if they play any instruments: if so, discuss the general “sound profile” of their instruments - why does their instrument sound the way it does? *Instruments sound different because of the harmonics they produce*
- Live instruments: Jon (guitar, violin) Brian (ukulele) Ian (bottles) Heather (flute, keyboard?)
- Play samples of the same note/melody from different instruments: *“Do the melodies sound exactly the same?”*

  from https://auditoryneuroscience.com/topics/same-melody-different-timbre

    - Looking at the respective spectrograms...
        - The note is the fundamental frequency (lowest red band on spectrogram)
        - Different instruments have different harmonic profiles
    - Timbre is the “color”/”flavor” of a sound, based in part on the other harmonics (which ones, relative intensity, etc) present

Part 3: Fundamental Frequencies in Music - Autotune

for reference, fundamental frequencies of notes in Western music:
https://auditoryneuroscience.com/topics/fundamental-frequencies-notes-western-music

- *“Q: Can Kanye West actually sing?”* *808s and Heartbreaks* (e.g. “Love Lockdown”) was entirely Autotuned and was a huge trend-setter
- *“What is AUTOTUNE?”* = processing that artificially “fits” sounds to semitones (e.g. A, A sharp, B)
- Graph autotune: graph w/horizontal dashed lines as semitones (label as A, A sharp, B, etc.)
    - Draw normal waveform that wiggles at and between semitones

    - Draw autotuned waveform that artificially/”unnaturally quickly” shifts between semitones
- DIY Autotune using Garage Band
    - Ask students to sing snippets of their favorite songs (“Happy Birthday” or the ABCs works too)
    - Play back using pitch correction
    - Discuss the associated perception: does a pitch corrected sample sound robotic? Why? *The processing shifts 1) exactly to semitones and 2) extremely quickly, things that human voices are not capable of doing.*

Part 4: Jam Session

Further time to explore:

- Pitch correction in Garage Band
- Spectrograms in spectrogram app/Audacity - play music in from a phone and walk through the resulting spectrogram
- How to play the real instruments

Debrief (5 minutes): Whole-group discussion to ensure *all* students are at least at the expected level of understanding

Schedule (expected time):

4:40-4:45 **Warm-up Activity**

4:45-5:00 **Lesson Introduction**

5:00-5:50 **Activities**

5:50-6:00 **Debrief**

Notes/Concerns/Issues: