

Speech (Motor/Language)

Concepts: Students will understand the role of the brain in speech production - How sounds are made? What do they “look” like?

- What is language? What is NOT language?
- Consonants are made when the vocal tract is completely or partially blocked.
- Vowels are made when the vocal tract is open.
- Spectrograms display the waveforms that make up phonemes and words.
- The brain is intimately involved in the production of the speech sounds that make up language.
- The brain sends signals to the muscles of the speech apparatus to control all of the features of the sounds that are produced.

Objectives:

1. Students will play with Audacity and learn how to analyze spectrograms
 2. Students will discuss how the brain is responsible for the coordination of speech
 3. Students will talk about the phonemes that make up spoken language and the anatomy that produces them
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Setup:

Materials:

- Laptops
- Diagrams of speech anatomy
- Downloaded videos of accents, fMRI, vocal folds, throat singing

Teacher Preparation:

- Download Audacity
- Print diagrams of speech anatomy
- Download videos

Classroom Preparation:

- Set up laptops: dump video files and install Audacity on several computers
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In the Classroom:

Warm-up Activity (5 minutes):

World accents video:

- Amy Walker Video <https://www.youtube.com/watch?v=3UgpfSp2t6k>

- British kid Videos
 - https://www.youtube.com/watch?v=dABo_DCldpM (swearing)
 - <https://www.youtube.com/watch?v=riwKuKSbFDs> (no swearing)

Lesson Introduction/Description (5 minutes): Open Socratic discussion about language and sound. Some guiding questions:

- “Is MUSIC a language?” (recap last week)
- “What is language? What is NOT language?”
- “How can a collection of sounds become a word or sentence that *means* something?”
Phonemes, or the sounds of a language, can be combined to produce words that have meaning.
- “What other ways can speech convey information?” (optional - we’ll get to this later in our actual linguistics class: geography, education, class, etc. through accents, slang, etc.)

Activity (60 minutes, roughly 30 minutes for each part):

Part I: What does speech look like on a physical level?

Starting questions:

- “What is a consonant?” *From a physical perspective, consonants are sounds produced with a partial or complete blockage of the vocal tract*
- “What is a vowel?” *From a physical perspective, vowels are sounds produced with an unobstructed vocal tract*

Looking at spectrograms in Audacity (see Notes below)

- Ask students to take turns producing the following sound samples:
 - The traditional vowels, a/e/i/o/u: i.e. “ah eh ee oh oo”
 - Bat/bet/bit/bot/but
 - He/ha/who
 - Other sample phrases
 - “A sore back is a real pain”:
<http://home.cc.umanitoba.ca/~robh/archives/arc0801.html>
 - “The good guys wear white hats”:
<http://home.cc.umanitoba.ca/~robh/archives/arc0805.html>
 - “Citrus doesn’t go with chocolate”:
<http://home.cc.umanitoba.ca/~robh/archives/arc0807.html>
 - “Nothing beats a fudgey brownie”:
<http://home.cc.umanitoba.ca/~robh/archives/arc0809.html>
- Point out different features of the spectrogram - frequency bands, intensity, which areas of the spectrogram correspond to which phonemes
- “How do different people’s voices differ while saying the same thing?”
- Spectrograms as puzzles: ask students to plug their ears/leave the room while the mentor records a sample, then see if the students can decode what was said based on the spectrogram

- They shouldn't be good at this (it takes a lot of practice), but after playing the sound sample it should be easy to connect parts of the spectrogram with phonemes
- Other inputs/extensions:
 - Music, especially autotuned - relate to previous auditory lesson
 - Accents
 - Non-linguistic sounds: snaps, claps, whistles, clicks, coughs, etc.

Part II: What does speech look like on a cognitive/motor level?

- Videos of speech apparatus moving during speech
 - fMRI: soprano vs. beat boxer <https://www.youtube.com/watch?v=M2OdAp7MJAI>
 - vocal folds producing different pitches
<https://www.youtube.com/watch?v=9Tlpkdq8a8c>
- Discussion points: “How does the brain control speech production? What are the stages from a thought to the sounds coming out?”
 - Deciding what to say
 - Communication between
 - Motor commands to speech apparatus
- Walk through the anatomy of the speech apparatus: “What muscles are involved in speech?” “What happens if you open/close [part X] while you are speaking? Try it.”
- BrainSTEM Glee Club: Ask students to exercise their singing(/or speaking) voice while feeling their neck/face. “What muscles/parts of your face and mouth do you feel moving/vibrating/tightening?” “How many muscles do you think are involved in helping you speak/sing?”
 - Scales, i.e. do-re-mi-fa-so-la-ti-do
 - Tongue twisters
 - ex. Amazing Grace, or anything really
- Broca's Aphasia: “What is it? How does it happen? What can you infer about the relationship between a lesioned area and the symptoms (generally)?”
 - Broca's aphasia ex. 1 (old school video):
<https://www.youtube.com/watch?v=goclUW3E-go>
 - Broca's aphasia ex. 2 (old school video):
<https://www.youtube.com/watch?v=f2liMEbMnPM>
 - Broca's aphasia ex. 3 (18 year old girl):
<https://www.youtube.com/watch?v=1aplTvEQ6ew>
- Throat singing: “The **harmonics** (fundamental and **overtones**) of a sound wave made by the human voice can be selectively amplified by changing the shape of the **resonant cavities** of the mouth, **larynx** and **pharynx**.^[1] This resonant tuning allows the singer to create apparently more than one pitch at the same time (the fundamental and a selected overtone), while actually generating only a single fundamental frequency with his/her vocal folds.”
 - Tuvan throat singing covers of pop songs
<https://www.youtube.com/channel/UCCG4okc-Ua7WwSitdZF7DpQ>
 - Xhosa throat singing <https://www.youtube.com/watch?v=H5ufUjLQBxk>

Debrief (5 minutes): Group discussion about throat singing as a way to wrap up the previous lesson and this week's lesson - "What do sound waves "look" like, whether from instruments or human voices? How does the brain control speech?"

Schedule (expected time):

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

4:45-4:50 **Lesson Introduction**

4:50-5:45 **Activity**

5:45-5:55 **Debrief**

Notes/Concerns/Issues:

For mentor reference:

- Spectrograms in Audacity: http://manual.audacityteam.org/o/man/spectrogram_view.html
- How linguists read spectrograms: <http://home.cc.umanitoba.ca/~robh/howto.html>

Minor changes in Audacity preferences:

1. In the spectrogram settings, click the box for "Show spectrum using grayscale colors". Yes, more color = more sciencey/sexy, but it's a LOT easier to see what's going on in grayscale
2. Given that, the default gain setting of 20 dB is fine (I had said change it to 0). You can even bump it up higher if you want, depending on preferred contrast.
3. Adjust "Window size" to either 1024 or 2048 from the default 256. There's no right way to do this, but this seems to look the best.

The changes make it a LOT easier to understand and pick out phonemes. If you do, you can go to Audacity > Preferences > Tracks > Spectrograms and set your values there, so you don't have to input the preferred values for each track - you can just click "Use preferences" (saves a few clicks). See the screenshot below - top track is me saying "A sore back is a real pain" and bottom track is me saying the vowels "ah ee oo eh oh" - for an example of what it looks like after making these changes.

Also, the amount of signal at a given point in the spectrogram is roughly correlated to the amount of air coming out. Thus, the darkest regions (across the frequency spectrum) are vowels, where the vocal tract is unobstructed, while the lightest regions are consonants where the air stops completely

(e.g. b, p, t, d, k, g), with consonants of partial blockage in between.

