LING 190 Module 6: Speech Development

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1. The Development of Speech in Human Infants

- 2 months: coos and makes gurgling sounds
  - We can see that even 2-month-olds are vocalizing
  - This includes crying, which is a very loud vocalization
  - Most babies, at this age, begin to coo.
- 6 months: coos develop primarily with an open vocal tract, but at 6 months, the babies beginning to move their superlaryngeal vocal tract, making more rhythmic sounds that begin to sound like consonants
- 9 months: lots of different sounds, including 'bababa' and 'mamamama'
  - this is called the 'babbling phase,' which just includes a repeating consonant-vowel pattern
- 18 months: several single words, and the words they're saying resemble the language that they are learning
- 2 years: sentences with 2 to 4 words.
- 4 years: storytelling, essentially fluent speech

1.1. Topics to cover

- development of vocal tract anatomy
- Kinds of speech babies hear and produce
  - testing developmental speech perception
  - baby speech production
    - How baby vocalizations change throughout age and how it improves
- How we perceive and change our speech in adulthood

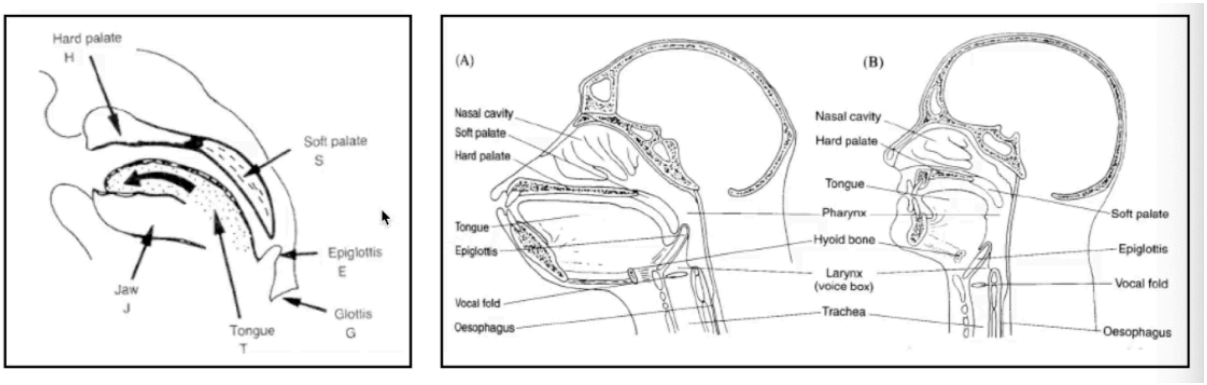
- puberty voice changes
- What are some of the factors that affect speech patterns and speech habits (which determine how we sound when we speak)

2. Anatomy

- How do infant and child vocal tracts develop
  - length of vocal tract, vocal folds, other structures
  - Sex differences between males and females
  - What are some factors that affect how the vocal tract develops

2.1. The newborn vocal tract

Very similar in shape to the ape vocal tract. Certain sounds are impossible or very difficult to produce at this age, since the vocal tract is physically different to an adult.



Some differences:

- No teeth in young babies
  - No teeth means no **dental** place of articulation
- Vocal tract length is much shorter
  - This will change later in development
  - Similar to apes, where the tongue can move forward and backward easily, but moving up and down is a problem.
- Newborns/young infants have less neuromuscular control over tongue and other active articulators
- The epiglottis is oriented differently than in an adult
- The vocal folds are also at an angle
- Larynx is still relatively high in the vocal tract

2.1.1. Childhood

- In the first 18 months of life, the vocal tract lengthens extremely quickly, which tracks with the development of the rest of the body at this age.
  - The vocal tract continues to lengthen into adulthood, but this slows down as is typical for the rest of the body.
  - It still takes many years for the vocal tract to reach its full length

- In the first few years, there aren't many differences between the length of a male and female vocal tract, but as age increases, adult male vocal tracts are typically much longer than female vocal tracts.

2.1.2. Puberty

- Puberty is a gradual change (5-6 year duration)
- Usually begins at 9-11 years of age
  - starts slightly earlier in females
- There are dramatic changes in vocal tract during this period
- **Vocal tract length** increases
  - During puberty, the larynx descends rapidly.
  - By the end of puberty, the larynx ends up twice as long as it was before puberty
- **Males, on average** have a longer vocal tract (during and after puberty).
- There is still quite a bit of overlap (in percentiles) between male and female vocal tract lengths.
- **Length of vocal folds** also change
  - Before puberty, the vocal folds are very similar between males and females
  - After puberty, male vocal folds thicken and become longer compared to female vocal folds
  - Because of the changes in length and thickness, an audible drop in F_0 pitch of male voices is noticeable (from an average of 280Hz to 120Hz).
    - Despite the average being around 120Hz, there is still quite a bit of variability.
    - Females, on average, have a pitch of around 220Hz

3. Baby Speech Perception

3.1. Methods to test infant speech perception

- **How** can you tell what a baby hears?

3.1.1. Fetal Heart Rate

Measuring changes in heart rate as a function of what is played through the belly of the mother. We know that after about 26-28 weeks of gestation, the fetal auditory system is relatively well developed, so during the third trimester, we can begin to observe behavioral changes in the infant.

- Heart rate can be measured from ultrasound (among other methods)
- Fetal heart rate is functional by 28 weeks of gestation
- Can play a recording of
  - The Mother's voice
  - Another female voice that is not the mother's
  - We want to see if the baby can recognize the differences in qualities between the mother's voice and another woman's voice
- It is observed that the fetal heart rate increases when the baby hears the mother's voice, but decreases when the baby hears another woman's voice
  - Interestingly, the heart rate decreases when the baby is introduced to new stimuli.

- It is theorized that the fetus's heart rate decreases when the baby is concentrating or thinking about something.

3.1.2. Habituation Method

When a baby is a little bit older, after it is born, we can use the habituation method. Shown to work on newborns, and infants up to about 6 months old.

- We use a pacifier hooked up to a measuring device.
- We play a sound to the baby, and measure how many "hard" sucks the baby makes on the pacifier.
- We play a sound over and over again, until the baby gets bored
  - At some point, their response rate will drop
- At this point, we switch the sound.
  - If their response rate goes back up, the baby recognizes this as a new sound.

What's interesting is that even newborns with only a few hours of experience with "full spectrum" speech can recognize the difference between similar consonant sounds: /b/ vs /p/ for example.

Habituation also works on Japanese Quail and Chinchilla babies. This suggests that many linguistically important distinctions (/pa/ vs /ba/ for example) may be universally distinguished across many animal species. However, this is not the case for **every** language sound. We know this because even for adult speakers, there are many sounds that exist in other languages that are not easily distinguished without language experience.

The fact that infants have no difficulty distinguishing between many sounds that adults cannot distinguish is a strong indicator that, as a baby moves from a "language-general" to "language-specific" stage, the infant's ability to distinguish sounds decreases.

3.1.3. Conditioned Head-Turn

We train babies to turn their heads in response to certain sounds and reward them by giving them visual stimulus.

4. Baby Speech Production

- Children's speech production
  - Overview of speech production at different ages
  - What do children produce well/poorly?

4.1. Cries at Birth

- Even at birth, vocalizations are influenced by language environment
  - There was a study that looked at the differences in the vocalizations of French babies and German babies. French intonation patterns have a more iambic (rising final syllable) quality, while German intonation patterns have a trochaic (falling final syllable) quality.
  - The key question is whether or not hearing these patterns in the womb would influence the production and quality of crying in newborn infants.

- When we look at a typical french cry, we see a rise towards the end of the cry, with the opposite pattern in German.

4.2. Stages of Vocal Development Before the 1st Birthday

Age (Months)	Developments
0	birth
1.5-3	cooing begins
4-6	vocal play
6-9	canonical/reduplicated babbling begins, /babababa/
8-12	non-reduplicated/variegated babbling, /bagabaga/, may resemble real words in the language being learned
12	first words

4.3. After the 1st Birthday

Age	Developments
12-18 mo	limited growth of phonetic inventory
19-24 mo	10 to 20 consonants, many words
25-36 mo	inventory growth; stuttering may occur
3-4 yrs	all vowels, most consonants
4-6 yrs	most sounds learned except for some fricatives
6-9 yrs	phonemic master completed
9+ yrs	most speech development is complete

4.3.1. Common Errors Children Make

- Why do children make these errors?
- In general, children make these mistakes because they are avoiding more difficult sounds.
  - Sometimes, they drop sounds that are hard to articulate
  - Sometimes they add sounds to make a word easier to say
  - Sometimes they substitute sounds (swapping manner or voicing)

Error	Target	Actual	Details
deletion	face /feɪs/ snow /snoʊ	/feɪ/ /noʊ/	omission of final consonant omission of the first sound of a consonant cluster
insertion	bicycle /'baɪsɪkəl/ scared /skɛɹd/	/'baɪsɪkəli/ ə'sk\rfɹd/	addition of vowel sounds that make articulation of segmental sequencies easier
substitution	shoe /ʃu/ pig /pɪg/	/tu/ /pɪk/	change in manner of articulation change in voicing

5. How we perceive and change our speech in adulthood

- What makes you sound like you?
  - Section 5.1 — Oculomotor Influences
  - Section 5.2 — Learned Influences

5.1. Organic Influences

- Height, weight, and other physical characteristics are not necessarily indicative of voice.
- Voice is determined by:
  - Length and mass of Vocal Folds
  - Length and shape of SLVT
  - Nature of soft tissues
- **On average, by sex and age:**
  - Men have longer SVLTs and VFs than women
  - Older speakers have slightly larger SLVTs and thinner VFs than younger speakers.
  - Older women's voices tend to get lower with age
    - due to hormonal changes

5.2. Learned Influences

How you sound is also determined by:

- Long-term configurations of the vocal tract
  - Larynx (source)
  - SLVT (filter)
- Consider these as **habits** of your vocal tract
  - You may hold your larynx or tense your vocal folds in certain ways that contribute to your voice quality.
  - You can move your SLVT in certain ways (dialetc, certain ways of speaking) that affects your accent, etc.

5.3. Voice Quality

- Holding your larynx in certain ways can affect the length of your SLVT, which affects filter.
- Holding your vocal folds in certain ways can affect breathiness/creakiness.