How do we solve the challenges of speech perception?

We use multiple acoustic and visual cues
We "perceptually warp" the cues
We use our knowledge of language

This week: Development and language learning

How did we learn to understand speech?
What did we have to learn, and what did we know at birth?
How can adults learn additional languages?

Theoretical perspective: Nativism vs. Empiricism

- B.F. Skinner (1957) Verbal Behavior
  - People learn language through 'operant' conditioning
  - Stimulus-Response-Reward shapes behavior
  - e.g., a rat learning to press a bar
  - Empiricism: All knowledge is a result of experience

- Chomsky (1957)
  - Innate abilities to process the world's languages
  - Development is a process of learning the characteristics of one's native language
  - Poverty of the stimulus: Language is not systematic enough to learn

The current view: Somewhere in between...

How can we test what babies perceive at birth?

- Techniques take advantage of natural behaviors (sucking, looking)
- Measures boredom and/or preferences for certain sounds or toys
- Need different techniques at different ages

Example 1: Non-nutritive sucking

- Sucking rate measures the baby's interest in a sound
- Babies suck less as they hear the same sound repeated over and over
- A change in a sound increases sucking again
- If they change their sucking rate when we change the sound, this tells us they heard the sound change

www.ehess.fr/centres/lscp/babylab/index.html
How can we test what babies perceive at birth?

Example 2: Preferential looking

- Older babies (6-11 months old) can learn to look at a light or toy in response to the sounds that they hear.
- Can measure preferences for a sound (i.e., the babies can control what they hear).
- A preference can be used to see whether they can tell the difference between sounds.
- Can also be used to see whether they remember a sound.
- Can also measure their ability to discriminate sounds.

[Image: Preferential looking example]

The Head-Turn Technique

- Measure neural responses using:
  - Electrodes
  - Blood flow measured through light.
- At the frontier, still needs much development.

[Image: Head-turn technique example]

Example 3: Neurological measures

- Neurological measures
- Measure neural responses using...
  - Electrodes
  - Blood flow measured through light.
  - At the frontier, still needs much development.

[Image: Neurological measures example]

What abilities are babies born with?

- Techniques take advantage of natural behaviors (sucking, looking).
- Measures boredom and/or preferences for certain sounds or toys.
- Need different techniques at different ages.

[Image: Baby behaviors example]

What abilities are babies born with?

A look at categorical perception...

- Eimas (1971) found that babies could categorically perceive consonants.
- Implies that the nativists were right.

[Image: Categorical perception example]
However, animals do the same thing!

- Monkeys, gerbils, starlings, budgies, etc. are all better at discriminating stimuli that cross human phonetic boundaries.
- Suggests that Eimas et al. results are based on auditory processing, not linguistic structures.

The abilities of infants change over the first year of life

- Infants are born with the ability to hear many (all?) of the world’s phonetic contrasts.
- Loss of ability to hear non-native contrasts around 6-12 months of age.

When does learning begin? In the womb!

1. Sound of blood through the umbilical chord
2. Sound of male voice reading a word
3. Sound of family conversation

- Infants are born with a preference for the pitch patterns of their mother’s language.
- They can distinguish native vs. non-native intonation, but not native vs. non-native phonemes.

How do babies learn? Statistical learning

- Even before babies can understand the meanings of words, they are paying attention to the sounds.
- Learn which types of sounds are more frequent than other.
- Learn which combinations of sounds occur with each other.

Statistical learning 1: Kuhl’s Native Language Magnet Model

- The most frequently heard sounds warp perception.
- The distribution of speech sounds changes the ‘basic cuts’ in the perceptual space that was provided by auditory processing.

/ŋ/ and /l/ ‘Perceptual maps’ for American English and Japanese speakers

- Physical Spacing of Stimuli

Iverson et al., 2003
How do babies learn?

**Vocal imitation**

- Infants tend to imitate adults
- As they get older, their imitation of adult vowels gets better
- Likely helps reinforce auditory perceptual learning

Kuhl & Meltzoff, 1996

**How do we help with statistical learning and imitation?**

**Child-directed speech**

- People from different cultures stretch their vowel spaces when talking to babies
- More distinct vowels = higher intelligibility
- Other factors too
  - High pitch, variable pitch and formant frequencies, slower rate

Kuhl et al. (1997)

Our current view of Nativism vs. Empiricism

- Infants have basic native abilities that will help them learn language
- Phoneme boundaries tend to occur where auditory processing is the most sensitive
- Babies are born with an interest in speech and faces
- Babies, at an early age, know the relationship between visual and auditory speech

- But from there, all of the details need to be learned empirically

One perspective on plasticity: Song learning by songbirds

- Songbirds must be exposed to species-specific songs within a critical period
- Their own songs will not develop normally if they do not hear adults singing at the critical time
- Their own songs cannot change after development is complete
- Changes in brain plasticity are regulated by hormones
  - i.e., biological limitations on learning

Doupe & Kuhl, 1999

Do humans also have a critical period for learning speech?

**Issue 1: Is early experience important?**

- Learning does not develop normally without early exposure to language
  - Complete deprivation from language causes profound impairments
    - Genie and ‘wild children’
    - Exposure before puberty seems important (possible hormonal link?)
    - Hearing impairments early in life affect later language abilities
    - Cochlear implants
      - Work best in children when they are implanted as early as possible
      - Do not work very well for adults who could not hear during childhood
    - Even childhood ear infections affect adult reading abilities

Early exposure to speech is very important and hearing impairments should be treated as early as possible
Do humans also have a critical period for learning speech?

Issue 2: Is there a loss of plasticity for learning over time?

- Informal observations...
  - Children learn new languages with little effort and can learn to speak without a strong accent
  - Adults must work hard to learn new languages and speak with a stronger native accent
  - Possible link to changes in the brain around puberty?

However, science tells us that this conclusion is not entirely true...

Sentence rating for L2 speakers with different ages of arrival

- Large effect of age of arrival on accent
  - People who learn English later speak with more of an accent
  - However, no clear critical period
  - People do not suddenly lose the ability to learn a second language at puberty
  - Loss of plasticity is gradual

Summary: Do humans also have a critical period for learning speech?

- Some evidence for the hypothesis
  - Early experience is very important for speech development
  - Learning is harder with increasing age
- But strong evidence against
  - No definitive biological change which stops learning
  - Learning can continue well into adulthood

Critical period hypothesis is probably false for human speech recognition
Today: Tutorial Sessions

Happy Christmas