Development of speech perception

Introduction to Speech Science Week 10

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 ones native language
  - Poverty of the stimulus: Language is not systematic enough to learn

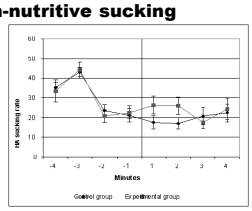
The current view: Somewhere in between…

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

How can we test what babies perceive at birth? Example 1: Non-nutritive sucking

e.g. www.ehess.fr/centres/lscp/babylab/index.html



- Sucking rate measures the baby's interest in a sound
- Babies sucks 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 use that they heard the sound change***

How can we test what babies perceive at birth? Example 2: Preferential looking

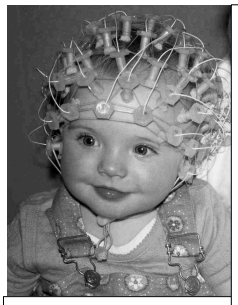
www.waisman.wisc.edu/infantlearning/infant_research.html

- 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

The Head-Turn Technique

The Head-Turn Technique

How can we test what babies perceive at birth? Example 3: Neurological measures



http://www.cbcd.bbk.ac.uk/index.html

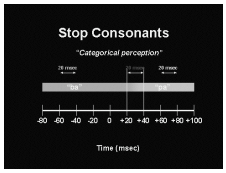
- Measure neural responses using…
  - Electrodes
  - Blood flow measured through light
- At the frontier, still needs much development

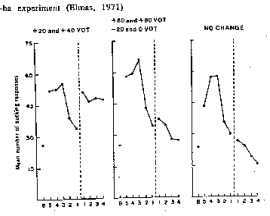
What abilities are babies born with?

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

What abilities are babies born with?

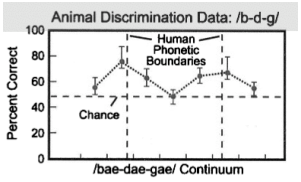
A look at categorical perception….





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

However, animals do the same thing!

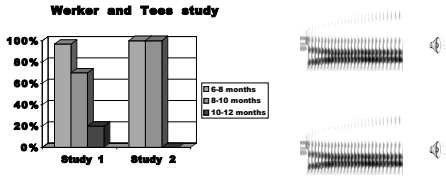


Kuhl & Miller (1978)

•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

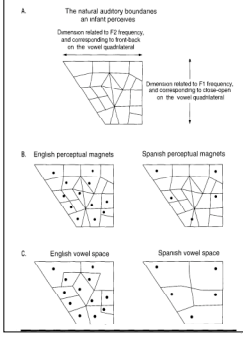
•They can distinguish native vs. non-native intonation, but not native vs. non-native phonemes

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

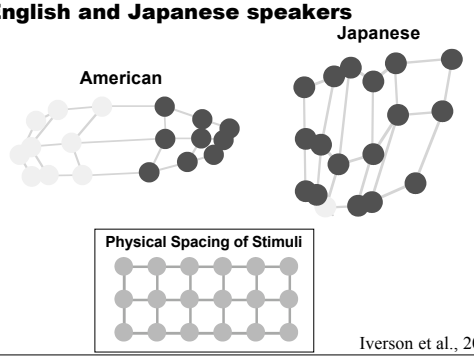
Statistical learning 1: Kuhl's Native Language Magnet Model



•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

/r/ and /l/ 'Perceptual maps' for American English and Japanese speakers

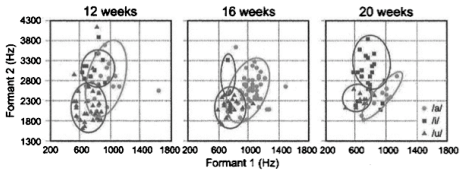


Iverson et al., 2003

How do babies learn?

Vocal imitation

Kuhl & Meltzoff, 1996

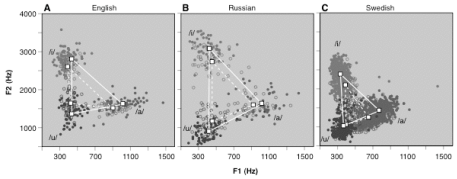


- Infants tend to imitate adults
- As they get older, their imitation of adult vowels gets better
- Likely helps reinforce auditory perceptual learning

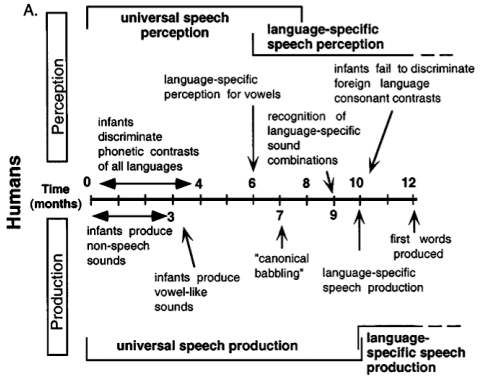
How do we help with statistical learning and imitation?

Child-directed speech

Kuhl et al. (1997)



- 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

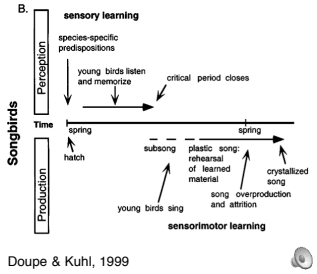


Doupe & Kuhl, 1999

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



Doupe & Kuhl, 1999

- 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

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

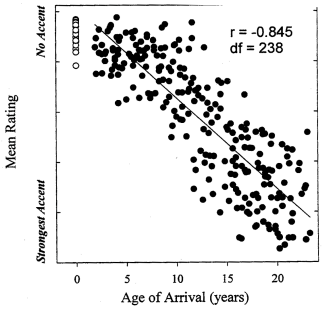
Do humans also have a critical period for learning speech?

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...

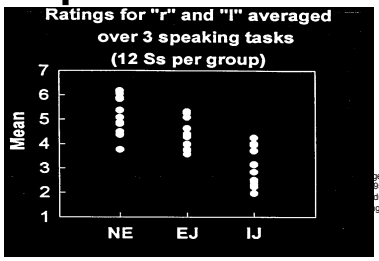
Sentence rating for L2 speakers with different ages of arrival



- 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

Flege, 1998

Effect of length of L2 exposure



ge, J.E., Takagi, N., and Mann, V. 995) Japanese adults can learn to duce English /r/ and /l/ accurately. guage & Speech, 38, 25-56

Ratings of the production of the /r/-/l/ contrasts by Japanese subjects having learned English as adults and lived in the US for 2 years ("inexperienced speakers") and for more than 20 years ("Experienced speakers").

Can you train L2 contrasts?

- 45 sessions over 3-4 weeks
- ***Method***: Perceptual identification w/ feedback
- ***Stimuli***: Large number of naturally spoken /r/-/l/ minimal pairs produced by 5 native speakers

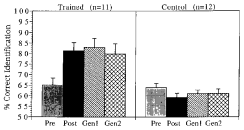
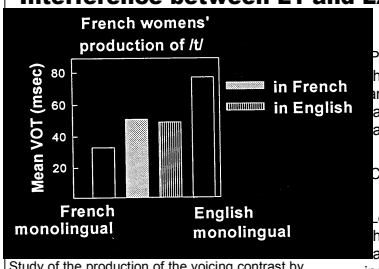


FIG. 1. Percent correct perceptual identification performance for trained (left panel) and control (right panel) subjects at pretest, post-test, and the two tests of generalization. The error bars represent one standard error from the mean.

Bradlow et al., 1997

- Training works!
- Can be used in clinical situations too...
  - Can help a child with language delays tune-into the differences between native language phonemes

Interference between L1 and L2 phonemes



Study of the production of the voicing contrast by French speakers who had learned English as adults and lived in the US for 10 years.

People use the same phonemes for both languages rather than having a separate set for each language

Causes interference

Learning of L2 phonemes is made harder when the individual continues to use L1

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