More on Speech Perception

Phoneme Discrimination

LDER Chapter 2

What is a phoneme?
- Smallest unit of language that signals a change in meaning
  - “pat” vs “bat”
- An abstract representation of actual sounds (phones)
- Different instantiations of a phoneme are allophones
  - e.g., “water” -- [t], [?] or [ʃ]

Infants discriminate all sounds

Adults discriminate sounds in their language

What happened?
The question:
- Infants distinguish minimally different phonemes
  - Even those not found in their native language
- Adults do not appear able to distinguish minimally different phonemes that are not in their native language
  - But adults are usually better than infants at tasks!
- What is responsible for this change from infant perception to adult perception?

How can we examine this?
- Need a procedure that is adaptable for both infants and adults!
  - Adults are not so good at sucking
  - Infants can’t push buttons
- Monitor continuous stream of syllables
  - /ba/ /ba/ /ba/ /da/ /ba/ /da/ /ba/ /ba/ /ba/ /da/
  - For adults and older children
    - Press a button whenever you hear target: /da/
  - For infants
    - Conditioned head turning paradigm

Conditioned head turning
- Assistant shows infant toys to keep them occupied
- Speech stimuli presented over speaker
- Infant trained (“conditioned”) to turn head towards speaker when stimulus changes
  - when infant turns head for a change, re-inforcer activates, displaying animated animals

What did they test?
- First Contrast
  - Hindi /Ta/ vs. /Ta/ has retroflex stop
  - /Ta/ has a dental one
  - Both sound like /Ta/ to English speakers
    - English /t/ is alveolar

Dissecting a stop consonant
- Silence
- Burst (release/aspiration)
- Vowel
- When does the vowel start?
  - Voice onset time (VOT)
    - Voiced stops: 10-30 ms
    - Voiceless: 40-100 ms
What did they test?

- Third Contrast
  - /ba/ vs. /da/
  - Difference in phonemic in both Hindi and English
  - Cued by place of articulation difference

Who did they test?

- English learning infants (aged 6-8 months)
- English speaking adults
- Hindi speaking adults
- Is this sufficient?
- Why not test Hindi-learning infants?

Results

- All three groups could discriminate /ba/ from /da/
- English learning infants and Hindi speaking adults could discriminate the two contrasts found in Hindi but not English
- English speaking adults had trouble with the two Hindi contrasts
  - After training, improved on voicing contrast but not retroflex/dental contrast

When do infants grow up?

- At what age does this change?
  - "Critical Period Hypothesis"?
    - Much earlier!
    - English speaking children aged 12, 8 and even 4 showed same pattern as English speaking adults
    - Hindi children aged 4 could discriminate Hindi contrasts when tested with the same paradigm

Before 4?

- Infants between 6 and 12 months tested:
  - On retroflex/dental Hindi contrast
  - On a new contrast from Nthlakampx (aka Thompson)
    - Glottalized velar /k/ 
    - Glottalized uvular /q/
    - Both sound like /k/ to English speaking adults

Between 6 and 12 months

- English learning infants could discriminate both contrasts
  - At 6-8 months old
  - But not at 10-12 months old
- What about Hindi and Nthlakampx infants?
  - 11-12 month old infants in both groups could distinguish contrasts in their native language
  - Perceptual loss not just an aging effect
  - Reflects language-specific experience!
Categorical Perception

Discrimination is % different over 20 ms intervals (1 vs 3; 2 vs 4; 3 vs 5; etc.)

Categorical Perception: /ba/ vs /da/

Formant transitions vary continuously as a function of place of articulation.

Infant Categorical Perception

- Create continuum of sounds (artificially) that varies between
  - Bilabial /ba/ - dental /da/ - retroflex /Da/
  - English learning infants aged 6-8 months
    - Distinguished proper boundaries between /ba/ and /da/ and /Da/
  - English learning infants aged 10-12 months
    - Distinguished boundaries between /ba/ and /da/ but NOT between /da/ and /Da/

What’s the explanation?

- Maintenance/Loss
  - Only phonemic contrasts present in the native language will be maintained, others are lost permanently
    - Loss may reflect developmental changes in the brain
  - Maybe this is too strong…

Do adults remember anything?

- Perceptual Assimilation Model
  - Non-native contrasts that assimilate into a single native category are lost
    - Hindi /t/ and /T/ both map to English /t/
  - Non-native contrasts that don’t assimilate well into a native category may be easier to discriminate
  - Non-native contrasts that are not remotely close to native categories should be well discriminated

Zulu

- Zulu clicks
  - [ ] (tsk-tsk)
  - [ || ] (horse sound)
- Adults (and infants of all ages) easily discriminate Zulu clicks
  - but only younger infants discriminate Zulu contrasts that are closer to English sounds
- Loss of phonemic contrast discrimination may reflect experience after all, and not necessarily brain-specific changes
What about vowels?
- In German contrast between:
  - /but/ and /bʊt/
  - (high back rounded vs. high front rounded)
- Adults make this discrimination easily
- For infants, experience seems to play a role earlier for vowels than for consonants
  - 6-8 month old infants discriminate the vowels, but not as well as they discriminate non-native consonant contrasts
- Vowels may be somewhat different than consonants

Summary
- Within the first year of life infants –
  - are learning the phonemes of their language
  - grouping them into categories
  - become less well able to discriminate non-native phonemic contrasts
  - For consonants when non-native sounds are similar to native ones
  - For vowels at a slightly earlier age

Language Discrimination
LDER Chapter 3

What's special about babies?
- Human infants
  - Discriminate phonemes categorically
  - Are sensitive to the rhythm of speech
  - Process natural speech differently than backwards speech
- Other species
  - insects, birds, primates, mammals
  - Perceive their own species-typical sounds categorically
  - Some also perceive human speech categorically

How to test for a difference?
- Same problem as for testing infants vs adults, but worse
- Need a paradigm that is comparable for both babies and monkeys
  - Babies: high-amplitude sucking
  - Monkeys: head-orientation response (similar to conditioned head turn paradigm)
Language Discrimination Task

- Tested Japanese vs Dutch sentences
- Test sentences were read by 4 native (adult female) speakers of each language
- Contrasted
  - Language: Japanese vs Dutch
  - Speaker: within each language
  - Forwards vs. backwards speech

Human Infants

- High-amplitude sucking procedure
- Native French speaking infants
  - Language change
    - Habituate to 2 speakers of one language (Japanese or Dutch)
    - Switch to 2 speakers of the other language
  - Speaker change
    - Habituate to 2 speakers of one language
    - Switch to the other 2 speakers of the same language
- Greater increase in sucking for language change than speaker change indicates newborns distinguish the two languages

Human Results

- The infants did not discriminate the two languages...
  - But, shouldn’t they have?
  - Yes, but...
  - Speaker variability seems to impair language discrimination ability of infants (this susceptibility goes away after a few months)
- With only a single (synthesized) voice
  - Preserves prosody; removes some phonetic detail
  - Infants did discriminate the two languages!
  - But only forwards, not backwards
    - Backwards speech may eliminate cues necessary to distinguish the two languages

Cotton Top Tamarins

- Head orientation response
- Native Cotton-Top speaking Cotton-Tops
  - Tested initially on their own species specific vocalizations, to ensure that test procedure worked
  - Tested on same language stimuli as human infants
- Habituation – recovery of head orientation to loudspeaker indicative of detection of difference

Monkey Results

- With natural speech
  - Tamarins dishabituated in the language change condition
  - more than in the speaker change condition
- With synthesized speech
  - Tamarins did not dishabituate more for language change than speaker change
  - But only for forwards speech!
  - Language change not detected with backwards speech

Summary

- Both human infants and cotton-top tamarins could distinguish Japanese and Dutch
- Speaker variability problematic for young infants but not cotton-top tamarins
  - Monkeys able to extract abstract linguistic information from a variable natural signal (babies catch up)
  - Monkeys handled synthetic speech less well than human infants (tamarins more sensitive to phonetic than prosodic contrasts?)
- Inability to distinguish languages when played backwards same for humans and monkeys
  - Suggests sensitivity to important aspects of speech
  - Low level details similar forwards and backwards