In the Beginning ...

- Eimas, Siqueland, Jusczyk, & Vigorito at Brown University adapted the High Amplitude Sucking Technique to study infant perception of speech sounds.
- Eimas et al. asked whether 1- and 4-month-old infants categorically perceived differences in voicing.
- Infants receiving a between-category change did recover from habituation, but infants receiving either no change or a within-category change did not recover from habituation.
- Results were substantially the same for both 1-month-olds and 4-month-olds.
- Therefore, infant perception of voicing appears to be categorical, just as in adults.
CAUTION: Preference Method

- Preference methods are widely used in infant research because they are adaptable to a wide age range and generally easy to administer.
- However, there are two significant problems with this class of methods.
- First, the stimuli themselves serve as reinforcers, so that an absence of preference is not good evidence of inability to discriminate.
- Second, results based on global measures of performance, not tied to individual stimuli.
Eimas et al. Possible Conclusions

• Categorical perception is innate
  This appears to be true.
• Categorical perception is specific to language.
  This has been shown to be false.
• Infant speech perception is essentially similar
  adult speech perception, except that infants
  must learn how phones are grouped into
  phonemes in the native language
  Let’s see.
Are the Units of Speech Perception the Same for Infants and Adults?

• What is the unit of perception for adults?

• Note Savin & Bever – adults are faster at monitoring syllables than phonemes, suggesting that the later are not directly involved in speech perception but are rather derived representations.

• On the other hand, adults can monitor for phonemes, do learn to read alphabetically, etc., suggesting some psychological reality for the phoneme.
What Units are Available to Infants?

• Jusczyk et al. (1995): two-month-olds familiarized with sets of bisyllables
  – [ba zi] [ba lo] [ba mlt]
  – [pae zi] [nE lo] [ko mlt]
• Two minute delay
• Infants tested on set that included e.g.,
  – [pa mul]
• Infants were significantly more likely to retain information about bisyllables that shared the same initial CV syllable.
Jusczyk et al. Bisyllables, Syllables, or Segments

• Infants familiarized with
  – [za bi] [la bo] [ma blt]
• Two minute delay
• Tested on sets that included
  – [ba nu] or [na bu]
• No recovery in either condition
• Taken as evidence for syllables as representational units, not evidence for segments.
Eimas 1999

• 3- and 4-month-old infants familiarized with sets of items containing
  – A common initial segment (monosyllables only)
  – A common initial syllable (in bisyllables)
  – A common final syllable (in bisyllables)

• Tested on sets containing
  – Novel exemplars of familiarized item
  – Novel exemplars without familiarized item

• Evidence for categorization of syllables, not segments
Our study

• Conditioned head turn with 6- 8-month-old infants
• Infants trained on simple contrast [de]-[ti] or [di]-[ti]
• After training, contrast embedded in longer strings
• Prediction – infants’ ability to maintain discriminative response will be a function of the complexity of the context in which the contrast is embedded.
• Question: what contributes to complexity?
Our results

- Six-month-olds showed decrements in performance as a function of the number of syllables in the context, regardless of the contrast on which they were trained.
- Eight-month-olds trained on \([de]-[ti]\) resembled the 6-month-olds.
- Eight–month-olds trained on \([dl]-[ti]\) showed decrements in performance as a function of the number of segments in the context.
What About Invariants?

• Several studies by Kuhl & colleagues show that infants can ignore variations in pitch & talker (notable for very long ISIs).
• No evidence for constancy across syllable (or even word) positions – this hasn’t been studied.
• Recent studies on spoken word recognition show that infants fail to recognize familiarized words when pitch, talker, speaker affect, stress, etc. change.
• However, when speech is slowed, infants do recognize words across these changes.
• These findings are consistent with an attractor model of perception.
Speech Sound Categories

- Infants, regardless of the parents’ language, are born with the ability to discriminate a universal set of phonetic contrasts.
- This ability declines as a function of specific linguistic experience (Eimas, 1978; Werker et al., 1981), and is not found in adults.
- Experience listening to a language may be necessary to facilitate perception of some phonetic distinctions (Eilers, Gavin & Wilson, 1979).
Speech Sound Categories

• Young infants can discriminate speech sounds according to phonetic categories that may not be used in their native language (Aslin et al., 1981; Lasky et al., 1975; Streeter, 1976; Trehub, 1976; Eilers et al., 1978).

• In contrast, adults seem to easily perceive sound differences which are used phonemically in their language BUT may not be able to identify or discriminate sound distinctions used in non-native language. (Lisker & Abramson, 1970; Singh & Black, 1966; Goto, 1971; MacKain et al., 1980; Miyawaki et al, 1975; Tees & Werker, 1982; Trehub, 1976).
Perception of Non-Native Contrasts

Werker & Tees (1981):

• comparison between English adults & infants and Hindi adults

• had to discriminate pairs of Hindi speech contrasts not used in English:

• place of articulation distinction:
  – voiceless unaspirated retroflex vs. dental
Werker & Tees (1981)

- Infants aged 6-8 months can discriminate these sounds as well as Hindi adults.
- English adults cannot make this discrimination.
- English children at 4, 8 & 12 years old were as poor as the English adults in discriminative performance.
Werker & Tees (1984)

• What is the developmental time period in which diminution of discriminative ability occurs?

• Results: Reaching criterion on Hindi contrast /t̪a/-/ta/

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Reaching Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-8 months</td>
<td>11/12</td>
</tr>
<tr>
<td>8-10 months</td>
<td>8/12</td>
</tr>
<tr>
<td>10-12 months</td>
<td>2/10</td>
</tr>
</tbody>
</table>
Conclusions

• The decline in the ability to discriminate non-native phonetic contrasts occurs within the 1st year of life.

• Infants being raised to speak Hindi sounds could discriminate the relevant contrasts at 11-12 months of age.

• Specific linguistic experience is necessary to maintain phonetic discrimination ability, otherwise the ability is lost by the age of 10-12 months.
Mechanisms of Change

• Gottlieb (1976) (an embryologist) provided an influential model of effects of experience on development. In this model, there are four basic ways in which early experience can affect perceptual development:
  – *Maintenance*: innate perceptual may require relevant experience if it is not to atrophy.
  – *Facilitation*: early experience may serve to attune abilities partially developed at birth
  – *Induction*: development of an ability not present at birth requires particular experiences.
  – *No effect*
Possible Theories of Perceptual Development

Aslin & Pisoni (1980) suggested that four types of theories may be relevant to phonological development. On their view, particular aspects of development may be due to one or a combination of these theories.
Universal Theory

- At birth, infants are capable of discriminating all possible phonetic contrasts.
- Early experience functions to maintain some of these contrasts.
- Absence of phonologically irrelevant (to native language) contrasts results in selective loss of abilities to discriminate these contrasts.
- Mechanism may be neural or attentional.
Attunement Theory

- At birth, infants capable of discriminating some phonetic contrasts, but discrimination is incompletely development and/or broadly tuned.
- Early experience serves to align/sharpen initial discriminative abilities.
- Relevant contrasts become more finely tuned, whereas irrelevant contrasts remain broadly tuned or become attenuated.
Perceptual Learning Theory

• Ability to discriminate any particular contrast is dependent on specific early experience.

• Rate of development depends on frequency of contrast, psychophysical discriminability of contrast, and infant’s attentional state.

• Phonologically irrelevant contrasts never discriminated better than contrasts present in learning environment.
Maturational Theory

• Ability to discriminate is independent of early experience.
• Age at which contrasts may be discriminated depends on developmental level of underlying sensory mechanism.
More Findings

• Werker: comparable patterns of non-native contrast loss found with Salish sounds
  uvular    phryngeal
• BUT: Best, McRoberts, & Sithole (1988) showed that both adults and infants maintain the ability to discriminate Zulu clicks.
• Why?
• These sounds are very unlike familiar speech sounds, therefore processed differently.
• Best proposed a “perceptual assimilation model”
More Findings

• Kuhl et al. (1991): vowel discrimination is asymmetric
  – Set up vowel triads, equally spaced in formant space.
  – One vowel was prototypical of a native language category.
  – Infants were habituated either to the prototypical vowel or a non-prototypical vowel; in both cases they were tested for recovery when the third vowel was presented.
  – Recovery when habituated to non-prototypical vowel, but not when habituated to prototypical vowel.

• On the basis of these findings, Kuhl proposed a “perceptual magnet theory”
More Findings

• Anderson, Morgan, & White (2003)
• Question: what drives formation of native language phonological categories?
• Conclusion: Frequency
• What they did: Tested infants on two contrasts, each bracketing a native language phoneme. Hypothesized that contrast bracketing more frequent sound would be lost earlier.
• What they found: 6-month-olds discriminated both contrasts equally well. 8.5-month-olds still discriminated the velar contrast, but could no longer discriminate the coronal contrast.
More Findings

- **Strengths:** First study to relate precise input statistics to infant discrimination.
- **Weaknesses:** Only studied one pair of contrasts, so didn’t rule out possible alternative explanations.
- **Further research:** Test discrimination cross-linguistically, in cases where statistical patterns differ.