Peter W. Jusczyk: How Infants Begin to Extract Words from Speech

- The problem of speech segmentation
  - Foreign language – where are the spaces between words?
    - Hungarian

- When do infants begin segmenting words?
  - Sensitivity to sound organization in second half of first year
    - 6 mo – can tell apart phonemes that are not in their mother tongue (/l/ vs /r/)
      listen equally long to good/bad sequences (/ŋ/ at start of word, /zn/)
    - 9 mo – lose non-native contrasts
      prefer words with permissible sounds
      prefer predominant stress
  - These are potential sources of info about word boundaries

Experiment: Jusczyk & Aslin
- For 30 sec infants familiarised with a pair of words; play passages
- 7.5 mo infants but not 6 mo infants listen longer to passages containing familiar words
  - same pattern when first exposure in fluent speech, second in isolation
- No effect when phonetically similar words were used (tup as training for cup)

Experiment: Houston et al
- 7.5 mo infants showed the effect when tested 24 hrs after familiarisation

Conclusions:
- Infants at age 7.5 mo can detect familiar words in fluent speech
- They are paying attention to actual words, and not just familiar phonetic patterns
- They encode information into memory about the sound pattern of words in speech

- How do infants segment words?
- Use stress?

Experiment: Jusczyk et al
- One group of 7.5 mo infants was familiarised with words like kingdom
  - they listened longer to passages containing these words than to controls
- Second group of 7.5 mo infants was familiarised with words like guitar
  - they did not listen longer to passages containing these words than to controls
- Third group of 7.5 mo infants was familiarised with words like tar
  - they listened longer to passages containing words like guitar than to controls
- By age 10.5 mo English-learners do detect familiarised weak/strong words in fluent speech

Conclusions:
- Infants at 7.5 mo correctly segment bisyllabic words with predominant stress pattern, but not those with less common stress pattern
- They appear to mis-segment the weak/strong words at the strong syllable boundary
- By age 10.5 mo English learners do not rely exclusively on stress cues for segmentation
Experiment: Saffran et al
- 8-month old infants familiarised with synthetic speech composed of four different 3-syllable sequences ('words') produced with flat stress
  - order of syllables within 'words' fixed (tibudo), 'word' followed equally often by 1 of 3 others
  - so, probability of /ti/ being followed by /bu/ is 1 inside a 'word', but much smaller across 'word' boundaries
- Tested using isolated versions of two of the words in the sequence, and two part-words composed of last syllable of one word plus the first two syllables of another word from familiarisation
- The infants did distinguish the words from the part-words, treating the part-words as novel
Conclusions:
  - When such statistical regularities are present in speech, infants can use them for segmentation

Experiment: Mattys et al
- 9-month old infants presented with two types of lists of CVCCVC items. In one, the CC was one that occurs in English much more often between words; in the other, the CC was one that occurs more often within words
- Infants listened significantly longer to lists with the within-word CC sequences
- When pause inserted or stress pattern changed to weak-strong, infants switched their preference
Conclusions:
  - By 9 mo, infants have learned how various phonotactic sequences are distributed w.r.t. word boundaries

Experiment: Jusczyk et al
- 9 month old infants familiarised with nitrates listened equally long to the test passage with night rates and nitrates (although 2 month old infants can tell apart nitrates and night rates)
- 10.5 month old infants did listen significantly longer to test passages with the familiarised item
Conclusions:
  - Between 9 and 10.5 months infants become sensitive to how allophonic cues are distributed within words

- Why are multiple cues necessary for word segmentation?
  - According to the studies above, infants towards the end of their first year are sensitive to a number of things relevant to word boundaries and speech
  - Too heavy a reliance on any one of the above characteristics can lead to mistakes
    - Onsets of words beginning with a weak stress would be lost using only prosodic clues
    - Reliance solely on statistical regularities results could lead to confusion between pieces of candle, can deliver, and can delphiniums thrive here?
    - Phonotactic errors of word boundary location can occur
● More empirical research is needed, but:
  ○ Stress-based and statistical cues are available earlier (in English learners) than are phonotactic and allophonic cues
  ○ This could be because infants need to have some sense of what they hear as word-size chunks in order to process the other pieces

● Segmenting Words When Extracting Meaning
  ○ Just because an infant can recognize a primed word or sound pattern at 7.5 months does not mean that the child understands what the word means.

Tests of meaning related recognition
Experiment: Fernald et al.
  – Tested 15 moth-olds for a target word
  – When shown two pictures, and heard a sentence with a target word a the end of a sentence, 15 month-olds looked at the correct picture significantly more often than when target word was in the middle of the sentence
  – 18 month-old infants responded equally well to the target word in the middle or at the end of the sentence
Other experiments: Jusczyk et al
  – When 7.5 month-olds were given the same test, the results were much more varied

● So, why do 15 month-olds have difficulty with targets in non-final position?
  ○ Linking word to picture might be too hard a task when combined with demands of word-segmentation
  ○ Placing the target word at the end increases the infant’s ability to recognize it
  ○ Stager and Werker have found that the increased demands of word learning lowered infants’ speech discrimination ability (14 month old subjects)
  ○ By 18 months, infants become faster and more accurate at associating words with pictures, and, by 24 months, are faster still
  – By 24 months, infants and adults test about the same

Conclusions
● Some capacity for word segmentation at 7.5 months
● Usage of prosodic and statistical cues leads to phonotactic and allophonic ones
● Overall, many types of information must be integrated to make sense of speech
● Over time, especially in the second year, lots of progress is made

David Ingram: Phonological Development: Production

Introduction:
● Children aged 1.6-4.0 years: 50 word vocabulary
● Important Stage: “The phonology of simple morphemes”
Example- Jespersen (1922): children in different linguistic communities show a tendency to replace velar stops with alveolar ones.
  ● The child who says [tæt] for cat will also say [do] for go.

Phonological Processes: sound law
● universal set of hierarchically ordered procedures used by children to simplify speech
● Stamp: phonological development = gradual loss of simplifying processes until the
child’s words finally match their adult models

**Substitutions:**
comparing adult words to those the children use

- **Place difference:** [but] for book
- **Stopping:** Fricatives, and occasionally other sounds, are replaced with stops.

Ex: English- (2.9) sea [tj]; sing [tj]
French- (1.9) fleur ‘flower’ /pj/ replaces /f/; chaud ‘hot’ /t/ replaces /f/

- **Fronting:** Velar and palatal consonants tend to be replaced with alveolar ones

Ex: English- (2.0) shoe [zu]; shop [zap]; call [ta’]; coat [dut]
Polish- (1.11) [tʃasu] ‘time’ [ts’asu]

Two kinds including fronting of palatals and fronting of velars
-Children may show one and not the other

- Process interacts with stopping, so child may replace [ʃ] with [t]

- **Gliding:** A glide [w] or [j] is substituted for a liquid sound, i.e. [l] or [r]

Ex: English- (2.1) lap [jæp]; leg [ljek]; ready [wedi]
Estonian- (1.9) raha ‘money’ [jaha]; Rosbi ‘Robert’ [jobi]

Substitutions used in phonological processes may be highly influenced by the child’s phonological system, not just by universal tendencies.

- **Vocalization:** A vowel replaces a syllabic consonant, a process esp. in English
Ex: English- (1.9) apple [apo]; bottle [babu]; bottom [bada]; button [bätå]; dinner [dindå]

- **Vowel Neutralization:** Nasal vowels tend to be changed into oral vowels and vowels in general are often centralized, i.e. [a] or [Λ].
Ex: English- (2.0) back [bat]; hat [hat]; hug [had]

Vowel Neutralization usually occurs earlier and doesn’t affect this part of development.

Assimilatory Processes: assimilate one segment in a word to another

- **Voicing:** Consonants tend to be voiced when preceding a vowel, and devoiced at the end of a syllable.
Ex: English: paper (2.3) [bebə]; (2.7) [bebə]; (2.7) [pepə]; (2.8) [pεpə]

(1.5) pig [bɪk]; paper [bɪpi]; toes [dos]

- **Consonant Harmony:** In C1VC2 (X) contexts, consonants tend to assimilate to each other in certain predictable ways. The three patterns that occur are:

  (i) Velar Assimilation: Apical consonants tend to assimilate to a neighboring velar consonant.
Ex: (1.7) duck [gæk]; sock [gæk] (2.2) tickle [gɪɡu]

  (ii) Labial Assimilation: Apical consonants tend to assimilate to a neighboring labial consonant.
Ex.: tub [bʌb]; table [bʌb]; steps [beps]; tape [bεp]

  (iii) Denasalization: A nasal consonant will denasalize in the neighborhood of a non-nasal consonant.
Ex: French (2.1) mouton ‘sheep’ [pɔtø]; (2.2) monsieur [pofo]

- **Progressive Vowel Assimilation:** An unstressed vowel will assimilate to a preceding (or following) stressed vowel.
Ex: English- (2.0) flower [fə wa]
More on voicing: voiced consonants are actually voiceless unaspirated ones.

Studies:
- Smith (1973): Showed a gradual shift from a voiced substitution to a voiceless unaspirated to the correct voiceless aspirated.
- Bloch (1913): French-learned daughter voiced prevocalic consonants at the beginning of her phonological development (French [p] is voiceless unaspirated).
- Gilbert (1977): Voice onset time for voiceless stops is less stable and takes longer to develop than for voiced ones.
- Menn (1975): proposed that there is a strength hierarchy that determines the direction of assimilation, in which weaker consonants become to stronger ones.
  - From strongest position to weakest, is velar, labial, dental.

A sample from Menn’s son is as follows:
1. b-d, t e.g. bed [bed]; boots [bɔts]
2. k-p, d e.g. cup [kʌp]; cuddle [kʌdʌ]
3. t-b→b-b e.g. tub [tʌb]; table [tʌbɪl]
4. b-g→g-g e.g. big [gɪg]; back [gæk]
  - Rule: C1 assimilates to C2 if C1 is weaker than C2 on the strength hierarchy.
  - Vowels develop rapidly, so progressive vowel assimilation is usually lost early.

Syllable Structure Processes:
Phonological processes which motivated by the tendency to simplify syllable structure to CV.
- Fricatives are easier to produce postvocally than prevocally
  - Cluster Reduction: A consonant cluster is reduced to a single consonant.
    Ex: English- (1.11) clown [klaʊn]; play [pleɪ]; train [teɪn]; dress [dɛs]
    German- (2.2) fliegen ‘fly’ [fiːkən]; grosse ‘big’ [gʊsə]
  - Deletion of Final Consonants: CVC syllable reduced to CV by deleting the final C.
    Ex: English- (1.5) bib [bɪ]; bike [baɪ]; more [mɔr]; out [aʊ]
    French- (2.0) air [ɛ]; allumette ‘match’ [me]; assiète ‘plate’ [a.se]

*Direction of the deletion is also predictable
  - Deletion of Unstressed Syllables: An unstressed syllable is deleted, especially if it precedes a stressed syllable.
    Ex: English- (1.9) banana [nænə]; (2.3) granola [ɡrənə]
    Romanian- (2.0) masina ‘the car’ [mi.na]; papusă ‘doll’ [puʃa]
  *The deletion both of final consonants and unstressed syllables is also frequent, although the latter seems to persist longer than the former.
  - Reduplication: In a multi-syllabic word, the initial CV syllable is repeated.
    Ex. English- (1.9) cookie [ɡeɡe]; TV [didi]; water [wawa]
    French- (1.11) asseoir ‘sit’ [sisi]; bavette ‘bib’ [vevɛ]
  *Reduplication occurs quite early in children’s speech and is often lost by the time the stage under discussion begins. Children vary greatly in their tendencies to reduplicate.

Other Aspects of Phonological Development
System being observed through the children is not static, but dynamic.
- Phonetic Variability: children vary in their pronunciation of words.
  - Child 1.6 said these different words for blanket on the same day: [bwati], [bati], [baki], [batit]
  - Bloch (1913): During the months preceding 1.9, vocabulary is limited to around 40 words, and pronunciation is more fixed.
  - Phonological processes are lost not suddenly, but gradually
Children will usually have *frozen forms* in their speech: pronunciations that occur early in development and persist during a time when the child should show better pronunciation.

- Children will produce occasional *advanced forms*: productions that are better than expected, given the child’s phonological abilities.
  - This description is inadequate: adult form + phonological processes = child’s form
  - There is 1) the adult form; 2) the child’s representation of the word; 3) the child’s spoken form.

First few months of phonological development are also characterized by relatively extensive homonymy Ex: ([bæt] (1.10) *bad, bark, bent, bite*)

- Priestley (1980): Problem with homonyms: child perceives the adult words as the same or adult perceives the child’s productions as the same

**Homonymy:**
- Longitudinal data indicates that the rate of homonymy decreases consistently over time and *the extent of occurrence becomes minimal for most children by age 2*

Non-isomorphic processes: Phonological processes have been assumed to be isomorphic in relating the adult form to the child’s production: i.e. a one-to-one correspondence between each element in the adult form and each one in the child’s.

- Priestly (1997)- son around 1.10-1.11 showed these words:
  a) banana [bajan] 1.10 chocolate [kajak] 1.10 c) carrot [kajat] 1.11 peanut [pijat] 1.10
  b) Brenda [bejan] 1.10 d) streamer [mijat] panda [pajan] 1.10

*Group A was by far the most predominant pattern. The processes are as follows:*
1) Change all multisyllabic words into the structure C1VjVC2
2) After cluster reduction, place the initial consonant of the adult word into the C1 position
3) If the second consonant of the adult word is an obstruent, place it into the C2 position (Group a)
4) If the second consonant of the adult word is a sonorant, drop it and place the next consonant into the C2 position (Group c)
5) If the second consonant is a sonorant, but there is not a third consonant, place the sonorant into C2 (Group b)

**Phonological Preferences:** preferences by a child for specific articulatory pattern.
- Example: Young boy with preference for nasal consonants- uses many words with nasals and shows a tendency to assimilate non-nasal consonants to nasal ones: *cream* [mim] and [min] 1.9 and *sandwich* [nanu] 1.7 and [nænu] 1.9

There are three basic positions: initial, medial, and final.
- Not only do children over-use certain preferred sounds, they also may avoid words that contain sounds that they cannot currently produce.

**Summary:** Ages 1.6-4.0:
- The child’s language is dynamic in nature, so analysis needs to observe both old and new developments as well as the gradualness of phonological change.
- The phonological preferences of individual children will also contribute to differences.