Infant language acquisition

Speech perception and language acquisition in infancy
Infants need to be able to:

- Distinguish different phonemes from one another
- Distinguish different phonemes from one another in the context of other variation (talker, rate, etc.)
- Distinguish only the phonemes that are important in that particular language
- Learn what types of acoustic changes are important linguistically and which are not
- Distinguish their language from other languages, or distinguish different languages from one another (especially infants in bilingual homes)
Infants need to be able to:

• Learn to pay attention to speech itself, more than to face or gesture
• Learn how to pay attention to speech in the context of noise
• Learn what patterns are most common in their particular language
• Learn what patterns are most common within words vs. between words
• Learn to segment fluent speech stream into phrases and clauses
• Learn to segment fluent speech stream into individual words
• Store individual words in memory, and learn to associate them with meanings
• Learn what types of words co-occur with one another, and learn dependencies/relationships in the language
Main testing paradigms

• High-amplitude sucking paradigm (HASP)
• Conditioned head-turn paradigm
• Headturn preference procedure (HPP)
• Preferential looking paradigm
HASP

- Also known as non-nutritive sucking paradigm
- Infants who take pacifiers tend to suck on them more when they are alert and interested in something, and less so when they’re bored.
  - Researchers can thus measure sucking rate as an indication of interest level
- This procedure uses a pacifier attached to a computer that can detect changes in air-pressure, and thus can measure infants’ sucking.

HASP at birth
HASP, cont.

- One sound is presented until infants habituate to it.
- Then half the babies get a switch to a new sound, half continue to hear the old one.
- An increase in sucking on pacifier for the group with the switch suggests that infants can hear the difference between the sounds.

HASP at 2 months
HASP, cont.

Sample data from a HASP study.
Distinguishing between phonemes

• Infants can distinguish different phonemes differing in VOT.
  – Eimas, Siqueland, Jusczyk, & Vigorito (1971)
• Moreover, infants appear to perceive categorically.
  – Eimas (1975) examined the r-l distinction.
    – 2 and 3-month-old infants could better distinguish items that crossed the r-l boundary than items within a category.
    – This is a distinction that adult speakers of some languages cannot make.
    – Had these infants already learned English? Or do adults lose abilities they had as infants?
Distinguishing between phonemes, cont.

- Jusczyk, Pisoni & Mullennix (1992) examined the consequences of talker variability on infant’s ability to detect differences between speech sounds.
- Infants heard the word “bug” as spoken by 12 different talkers (6 male, 6 female).
- The sound either switched to yet another voice saying "bug" or to a voice saying “dug”.
- Infants still dishabituated more to a different syllable.
- Apparently they can hear phonemic differences even in the presence of other forms of variability.
Conditioned headturn paradigm

- Whenever there is a change in a stimulus, an electric toy is lit up and activated.
- Infants are thus trained to look at the toy whenever they hear a change.
- Then the target items are played, and an observer (who cannot hear the sounds) judges whether the infant heard a stimulus change by the infant’s actions.
The development of language-specific phoneme discrimination

- Werker & Tees (1984) examined adults & infants of various ages on two contrasts:
  - Hindi VOT contrast
  - Nthlakapmx contrast (aka Thompson; an Interior Salish, Native Indian language spoken in south central British Columbia)
Thompson/Nthlakapmx contrast

- **Adult data:**
  - All Thompson-speaking adults made the distinction
  - Only a few English-speaking adults could do so.

- **English-speaking infant data**
  - 8 out of 10 at 6-8 months of age (80%)
  - 8 out of 14 at 8-10 months of age (57%)
  - 1 out of 10 at 10-12 months of age (10%)
Hindi contrast

• English-speaking infant data
  – 11 out of 12 at 6-8 months of age (92%)
  – 8 out of 12 at 8-10 months of age (67%)
  – 2 out of 8 at 10-12 months of age (25%)
Longitudinal data

- 6 infants were tested on Hindi, Salish, and English contrasts at all 3 ages
  - All 6 reached criterion on the non-native contrasts at 6-8 months of age
  - At 8-10 months of age, all reached criterion on Hindi contrast but only 3 did on the Salish contrast
  - At 10-12 months of age, none of the infants reached criterion on either contrast.
Werker & Tees summary

• At first, infants can distinguish contrasts in many languages, without experience.
• There is a decline in this ability during the first year of life as a function of specific language experience – a re-organization of perception.
• Thus infants start out doing better than adults, and then lose this ability.
How does this happen?

• How would an infant come to realize what sounds are phonological in their language?
• One obvious possibility is differential exposure.
• But this does not work: nonnative contrasts often appear as allophones in the native language.
  – This means the infants do hear both members of the contrast.
• Learning must be based on the fact that the contrast does not change meaning.
  – A functional determination, not an exposure-based one.
Classes of nonnative contrasts

• Single-category assimilation
  – Those in which the contrasting phones are assimilated as variants of the same category
  – Ex: r/l for Japanese

• Opposing-category assimilation
  – Those in which the phones are assimilated as opposing members of a native contrast

• Category-goodness difference assimilation
  – Those in which one member is better assimilated to a native category than the other

• Nonassimilation
  – Those in which both members are dissimilar from all native contrasts and thus not assimilated at all
Nonassimilation

• Best, McRoberts & Sithole (1988) examined the last case, using Zulu clicks, which shouldn’t be similar to any native-categories for English listeners.
• English adults were able to distinguish these quite well, even though it was a nonnative contrasts
• Infants aged 6-8 months, 8-10 months, 10-12 months, and 12-14 months all discriminated Zulu and English contrasts equally well.
• The developmental change found by Werker is only for sounds assimilated to native-language contrasts; sounds that are not considered speech are not affected.
Distinguishing languages

• A majority of infants are raised in bilingual homes.

• Keeping different languages separate from one another is thus a requirement for accurate learning.

• By 4 days of age, infants can distinguish utterances in their language from utterances in other languages
Why so young?

• Infants hear their mother’s voice in utero.
  – The prosodic contours are transmitted via bone conduction.

• By the time they are born, infants already prefer:
  – Language over non-language
  – Their mom’s voice
  – Women’s voices more generally
  – Particular stories their mom read

• In one study, expectant mothers read stories aloud each day during the last 6 weeks of pregnancy – after birth, infants preferred the particular story their mom read.
  – DeCasper & Spence, 1986
Distinguishing languages, cont.

• Given this prenatal language experience, it makes sense that even at so young an age, infants would prefer listening to their mom’s language as well.

• But Mehler et al. also found that infants could not distinguish two unknown languages from one another.

• This implies that infants might have difficulty in households where there were multiple languages besides mom’s.
Distinguishing languages, cont.

• More recent work has shown that infants’ abilities depend on the specific languages.

• Languages can be divided into 3 rhythmic classes:
  – Syllable-timed
  – Stress-timed
  – Mora-timed

• Newborns can distinguish languages that are in different rhythmic groups
  – So can cotton-top tamarin monkeys

• But infants cannot distinguish languages that fall into the same class.
Learning the patterns of the native language

- Languages can differ in many ways:
  - Rhythm
  - Stress-patterns
  - Phonology
  - Phonotactic probabilities
  - Etc.
Head-turn preference procedure

- Infants sit on their caregiver’s lap in a test booth.
- On each trial, one of the side lights flash, and when the infant orients to the light, sounds come from that speaker.
- The experimenter records how long the infant looks at the “source” of the sound (the flashing light) as a measure of the infant’s preference.
In English, the majority of words have stressed (strong) initial syllables.

By 9 months of age, American infants listen significantly longer to words with strong-weak stress patterns than to words with weak-strong stress patterns.

Infants show no preferences at 6 months of age.

This suggests that the preference develops as a result of increasing familiarity with the prosodic features of the native language.
Jusczyk, Friederici, Wessels, Svenkerud. & Jusczyk, 1993

- Examined infants’ preferences for unfamiliar words that either observed or violated native-language phonetic and phonotactic patterns.
- Used English & Dutch, which are similar prosodically, but differ in phonology.
  - For instance, Dutch allows clusters such as [vl], [kn], and [zw], at the beginnings of words.
- US 9-mo-olds, but not 6-mo-olds, listened significantly longer to words with English sound patterns than Dutch sound patterns.
- Dutch 9-mo-olds showed the opposite pattern.
Jusczyk et al., 1993, cont.

- When the languages tested differed in their prosody (e.g., English vs. Norwegian), even American 6-mo-olds listened significantly longer to the English words.
- It appears that prosodic information comes first, and then phonological.
Jusczyk, Luce & Charles-Luce, 1994

- Investigated whether infants are sensitive to the frequency with which phonetic patterns appear.
- Two types of lists of monosyllables were presented:
  - High-probability lists (HPLs) contained items with phonetic patterns that occur frequently in English words.
  - Low-probability lists (LPLs) were composed of items with phonetic patterns that appear infrequently in English words.
- Nine-month-olds but not 6-month-olds listened significantly longer to the HPLs.
Babbling

• Early theorists believed that babbling was
  – Its own stage of development that was entirely separate from later language development.
  – Unrelated to language experience.

• Now researchers believe there is continuity from babbling stages to later language acquisition.

• Although infants start out babbling the same way, they move towards babbling “in their native language.”
  – That is, they start moving towards using the sounds that occur in their particular language.
Boysson-Bardies, Sagart & Durand, 1984

• Recorded samples of babbling from infants
  – From different language backgrounds (French, Arabic, and Chinese)
    – From different ages (6-, 8-, and 10-months of age)
• Played recordings to adult speakers of French.
• Adults were asked to identify which infants were from their own linguistic community.
• Adults were able to identify the infants by the time they were 8 months old.
Boysson-Bardies, Sagart & Durand, 1989

• Acoustically examined the vowels babbled by 10-month-old infants.
  – 1047 vowels
  – 20 infants
  – 4 language backgrounds (French, English, Cantonese & Arabic).

• There were consistent differences among all four groups of infants at this age.
What is common among all of these studies?

• This learning is taking place during the first year of life.

• Infants are learning many aspects of the sound patterns of their native language during the first year of life.

• An infant who cannot hear during his or her first year is going to be very far behind.
Segmentation: Jusczyk & Aslin 1995

- Infants were familiarized with two words, and then tested with fluent speech stories that either did or did not contain those words.

_The feet were all different sizes. This girl has very big feet. Even the toes on her feet are large. The shoes gave the man red feet. His feet get sore from standing all day. The doctor wants your feet to be clean._

_His bike had big black wheels. The girl rode her big bike. Her bike could go very fast. The bell on the bike was really loud. The boy had a new red bike. Your bike always stays in the garage._

• By 7.5 months, infants listened longer to passages containing the words they’d heard earlier; at 6 months of age, they did not.
• Similar results when passages were presented for familiarization, and words in isolation were tested.
Follow-up studies

• While infants can generalize from one voice to another of the same gender, they couldn’t cross genders at this age.

• They could a few months later (10.5 mo.)
  – Houston, 2001

• 2-syllable words:
  – For words like candle & doctor, which have the typical stress pattern for English, the infants performed well.
  – But for words like guitar & beret, they failed…
Follow-up studies, cont.

• Instead, for a passage like the following, infants will pick “vice” as being the word.

  Your device can do a lot. Her device only fixes things. My new red device makes ice cream. The pink device sews clothes. We don’t need that old device. I think that it is a plain device.
Follow-up studies, cont.

• If that 2nd syllable is followed by a consistent next word, infants will pick out a 2-syllable sequence starting with a strong syllable.
• So for a passage like the following, infants will pick “prizin” as being the word.

  We’ve got a big surprise in store for you. Her surprise in the barn is big, too. But it will be a very plain surprise in the box. Your surprise in the closet is very exciting. We hid this red surprise in Joan’s house. The pink surprise in the hallway will astonish you.
Attending to one voice in noise

• Same task as Jusczyk & Aslin, but with a distractor voice during familiarization.
• Can infants still learn the words?
• It depends on:
  – Signal to noise ratio.
    • Infants only show later recognition of the target words when they were louder than the background voice.
  – Whether the target voice is known to them.
    • Infants listening to their own mom will succeed in conditions where infants listening to another mom will not.
  – Whether there is visual information, or just audio information….
Attending to one voice in noise, cont.
Attending to one voice in noise, cont.

- Infants who can see the face of the person talking succeed in conditions where they would otherwise fail.
- Surprisingly, though, it does not have to be an actual face – any visual information that is correlated with the audio information helps them
  - so an oscilloscope display also works
Word learning

• 4.5-month-olds prefer listening to their own name than to other names.
  – Mandel, Pisoni & Jusczyk 1995

• But this really only shows that the infants found that word familiar, not that they knew it referred to them.
Preferential looking

- Infants see two television screens simultaneously, showing different pictures.
- They hear a voice telling them to find a particular picture.
Preferential looking

• Here, infants might hear, “Where is clapping? Find clapping now.”

• The infant’s looking behavior is videotaped, and later coded. The measures are the amount or percentage of time watching the matching television.
Tincoff & Jusczyk, 1999

- Showed 6-month-old infants videos of their own mom and dad, while hearing a voice saying “mommy” or “daddy”.
- Infants looked longer at the appropriate video, showing that they knew the meaning of these two words.
- Infants did not do so for other women and men – so the words were specific to those individuals and did not generalize.
- In a 2nd study, they took videos of hands & feet. Infants at this age would look at the appropriate video for that, as well.
Pause-insertion studies

• By 7 months, infants prefer listening to stories with pauses at clause boundaries than to stories with pauses within clauses.
• This suggests infants can identify clauses.
  – Hirsh-Pasek, Kemler Nelson, Jusczyk, Wright & Druss (1987)

Coincident version:
  Cinderella lived in a great big house / but it was sort of dark / because she had this mean, mean, mean stepmother. / And, oh, she had two stepsisters / that were so ugly. / They were mean too.

Interrupted version:
  … in a great big house but it was / sort of dark because she had / this mean, mean, mean stepmother. And, oh, she / had two stepsisters that were so / ugly. They were mean / too....
Pause-insertion studies, cont.

• By 9 months, infants show the same type of preference for phrases.

Coincident version:

The little boy at the piano / is having a birthday party. All of his friends / like to sing. The happy little boy / loves to play music for his friends. The little boy’s parents / gave him the piano for his birthday. The boy and his friends / are having a good time.

Interrupted version:

The little boy at the piano is having / a birthday party. All of his friends like / to sing. The happy little boy loves / to play music for his friends. The little boy’s parents gave / him the piano for his birthday. The boy and his friends are having / a good time.
Pause-insertion studies, cont.

• By 11 months, infants show the same type of preference for words.

Coincident version:

Some very / big animals live at the zoo. These very / big animals are elephants. (Oh boy!) The smaller baby / elephant is walking with her mother. Both / the mother and the / baby have long trunks instead of noses. The baby / elephant / and her mother are looking for food. Plants, grain and / peanuts are good / food for elephants.

Interrupted version:

Some very big ani / mals live at the zoo. These very big animals are ele / phants. (Oh boy!) The smaller baby ele / phant is walking with her mother. Both the mo / ther and the baby have long trunks in / stead of noses. The baby ele / phant and her mo / ther are looking for food. Plants, grain and pea / nuts are good food for ele / phants.
Relationships among words

• There have been a few studies looking at patterns of occurrence among words.
• These studies use the same speech perception methodologies, but focus on slightly older infants (2nd year of life).
Presented pairs of passages that were identical except for the placement of certain function words.
  – In the natural passages, each function word occurred in its proper sentential position.
  – In the unnatural passages, the function words were misplaced by exchanging them.

*Is* bike with three wheels *a* coming down the street. Johnny *that* seen *had* bike yesterday. *Was* lady with him *the* his aunt. *Was* red bike *this* missing for a day. *Had* cover *that* fallen on it. We *the* found *had* bike next to her garage.

Infants did not prefer the natural passages until 16 months.
  – Shady (1996)
Dependencies among words

• In English you can say
  – *He is coming* and
  – *He can come* but not
  – *He can coming*

• “can” and “–ing” do not co-occur, but “is” and “-ing” do.

• 18-month-olds, but not 15-month-olds, prefer passages that contain the well-formed dependency over ones with an ungrammatical combination.
  – Santelmann & Jusczyk, 1998
Dependencies among words, cont.

• But this depends on the memory load - the number of syllables in between the “is” and the “–ing”.
• They added adverbial relationships of different lengths.
  – He is digging
  – He is always digging
  – He is almost always digging

• When a two-syllable adverbial was present, 18-month-olds continued to listen significantly longer to the natural than to the unnatural passages.
• When longer adverbials (3 or 4 syllables) were used, the preferences for the natural versions disappeared.
Summary of infant skills

• Distinguish phonemes
  – With development, lose the ability to distinguish nonnative contrasts
• Distinguish languages
  – Native vs. nonnative
  – Across rhythmic classes
• During first year of life, infants learn to prefer:
  • Infants learn to prefer native stress patterns
  • Infants learn to prefer native phonology & phonotactics
  • Infants learn to detect phonotactic probability
  • Infant babbling begins to incorporate native phonology