COGNITIVE, PERCEPTUAL, AND MOTOR DEVELOPMENT (CH. 4)

COMD570: Language Development

Sign(s) of the day

- Animals
  - Cat
  - Dog
  - Mouse
  - Rat
  - Horse
  - Cow
  - Bird
  - Chicken
  - Duck

Neonatal Sensation/Perception

- Neonates (newborns) can see, hear, smell, taste, and feel
  - **Vision:** 8-15” distance, specific preferences
  - **Hearing**: well developed at birth, love human voices, and prefer music over noise
  - **Smell:** recognize mother’s smell
  - **Taste**: can perceive differences between sweet, sour, and bitter
  - **Touch**: like to be touched; reacts to changes in temperature and pressure
  - **Vestibular:** well-developed (inner ears reach their full development by 20 weeks gestation)
- Quantity and quality of sensation improves after birth

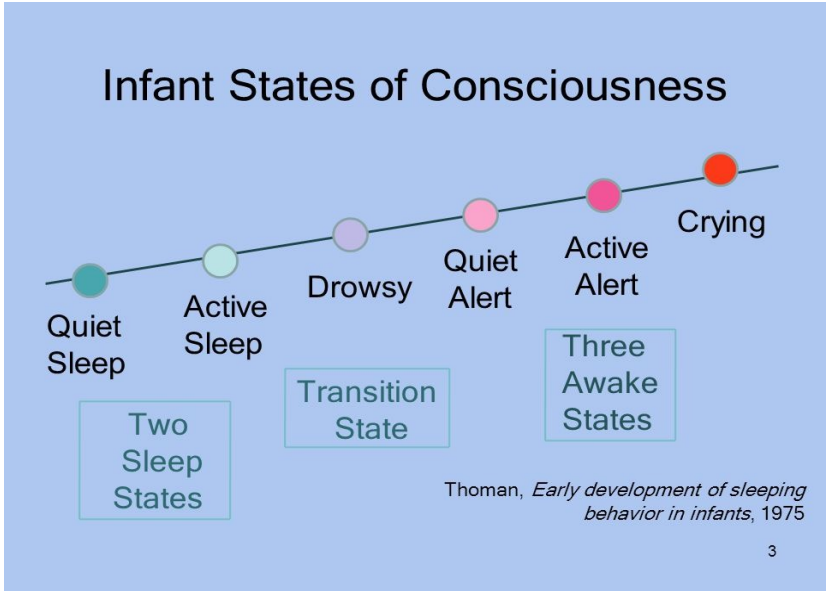
Visual perception in infancy

- Newborns: see 8–15” in front of them
- Prefer movement, novelty, color, and faces
- Acuity nearly adult like by 1 year
- Depth perception developed by ~7-8 months

- Exposure to light and complex patterns necessary for normal visual development

Biological Rhythms

- Newborns spend about 18 hours per day sleeping, 50% in REM.
- Shorter cycles of arousal occur throughout day
- Best able to attend to and learn from environmental stimuli when they are in “Quiet Alert” or “Active Alert” states
- Babies respond best to moderate intensity stimuli (“Little Goldilocks”)



Newborn's Reflexes

- https://www.youtube.com/watch?v=0V4x0iQODTk

TABLE 4.1 Selected Oral Reflexes of the Newborn

Reflex Name	Stimulation	Response
Phasic bite	Touching or rubbing the gums	Bite-release mouth pattern
Rooting	Stroking cheek at corner of mouth	Head turns toward side being stroked; mouth begins sucking movements
Sucking	Inserting finger or nipple into mouth	Rhythmic sucking

Sensory-motor development

- In order to successfully communicate using language, with respect to *sensory-motor* abilities, children must:
  - Be able to sense the signals of their linguistic community
  - Control the muscles of their vocal tract in order to generate those sounds
  - Hone in on and perceive the relevant phonetic contrasts in their language
  - Develop complex routinized motor procedures for generating speech sounds (phonetic procedures)

Prelinguistic “speech” production

Speech Motor Control

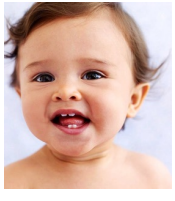
- Production of speech sounds is incredibly difficult and complex, and requires coordination of several elements:
  - Respiration (i.e., breathing)
  - Vibration at the larynx by the exiting air stream
  - Modification of resonance - the vibratory pattern of the vocal tract (nasal cavity, mouth, and throat)
  - Articulation of specific sounds using the jaw, tongue, teeth, and lips

Stages of preschool vocal development

0 weeks reflexive crying, biological-based sounds

6-8 weeks cooing

16 weeks vocal play begins



36 weeks reduplicated/canonical babbling

48 weeks nonreduplicated babbling

Biologically-related sounds

- Newborns make non-communicative and non-linguistic sounds that reflect biological functions:
  - Reflexive crying (https://www.youtube.com/watch?v=hdCbuF8_1p8)
  - Burping
  - Breathing
  - Sucking
- Helpful: infants' vocal cords vibrate & airflow through the vocal apparatus is stopped and started

Quasi-resonant nuclei (QRN)

- **QRN**: Brief, nasal, vowel-like sounds
  - Some consonantal elements
- **Cooing:** QRNs with closure or near closure at the back of the mouth
  - Occurs around 6-8 weeks
  - Result from being happy
  - First coos sound like one long vowel
  - https://www.youtube.com/watch?v=0yCSrb26MLc

Fully resonant nuclei (FRNs)

- Now includes resonance of the larygneal tone
  - Have much more acoustic energy than QRNs, including at higher frequencies
  - Still not fully vowel-like
  - Emerge after QRNs but before more advanced speech development

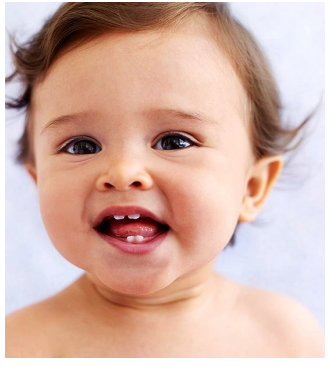
Vocal play

https://www.youtube.com/watch?v=Ttj3D65n4AM

- **Vocal play** : *word-like* speech production
  - Emerges around 16-30 weeks/5-6 months
  - Variety of consonant-*like* and vowel-*like* sounds
  - Some real vowel sounds heard at beginning
  - Recognizable consonant sounds (usually velars like k/g) can be heard around 2-3 months
  - Recognizable consonant sounds occurring near the front of the mouth (n/m/p/b/d) appear around 6 months
- **Marginal babbling:** long combinations of such sounds
  - Occurs at the end of the vocal play stage

Canonical/reduplicated babbling

- **Canonical/reduplicated babbling:** sequences identical speech syllables
  - Occurs around 36 weeks/6-9 months
  - Real speech (e.g. [dadada])
- Babbling unconnected to communication
  - Babies don't give any indication that they're trying to communicate through babbling
  - Show no sign that they expect a reply



Nonreduplicated/variegated babbling

- Different kinds of syllables (e.g. [dababagaga]
  - Emerges around 48 weeks/12 months
  - More variety in consonant and vowel sounds
- Infants incorporate prosody (e.g. pitch, rhythm) into their babbling
  - Sounds much more like they're trying to talk
  - However, the "words" of babbling are usually shorter than real words, max 1 or 2 syllables
- http://www.youtube.com/watch?v=_JmA2ClUvUY

Nonreduplicated/variegated babbling

- Stops (/p, b, t, d, k, g/), nasals (/m, n, engma/), and glides (/w, j/) constitute approximately 80% of the consonants in infant vocalizations and the first 50 words of English-speaking children
  - Relatively “simpler” articulation than fricatives, affricates, and liquids

- Vocal turn-taking begins to emerge – infants highly motivated by responses from adults

Cross-linguistic babbling

- Babbling reflects properties of the ambient language environment
- How do we know?
  - Recordings of 8-month-old babbling can be recognized by language
    - Japanese & French babbles contain more nasal sounds than Swedish & English babbles (De Boysson-Bardies, Sagart, and Durand, 1984)
    - Mandarin babbles use tone-like pitches while English babbles do not (Meltzoff et al. 2009)

- Even the crying of newborns seems to reflect the prosodic contours of the mother's native language! https://youtu.be/miQcbsSEhv8?t=1521

Sign language babbling

- Deaf infants babble with speech, but this tends to be limited to marginal babbling and drops off quickly
- But, deaf children *do* manually babble!
  - Shares many of the characteristics of spoken babbling (e.g., reduplication, progress through similar stages)
  - https://www.youtube.com/watch?v=SnZVpc3T60I

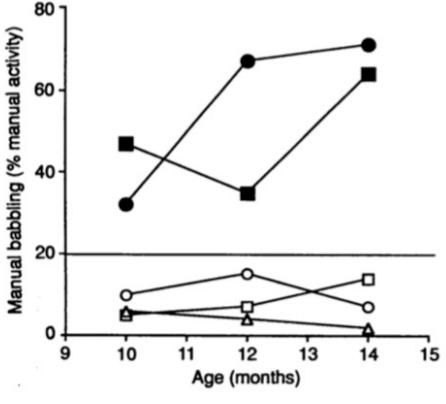


Fig. 1. Manual babbling as a percent of manual activity [manual babbling/(manual babbling + gesture)]. Open symbols represent the hearing children and closed symbols represent the deaf children (□, H1; △, H2; ○, H3; ●, D1; and ■, D2). The required syllabic ratio is 20% (line) syllabic to total vocal utterances for children to be classed in the syllabic vocal babbling stage of language acquisition (7). The deaf children met and surpassed this ratio in their manual babbling, but the hearing children did not.

Petitto & Marentette, 1991

Next steps

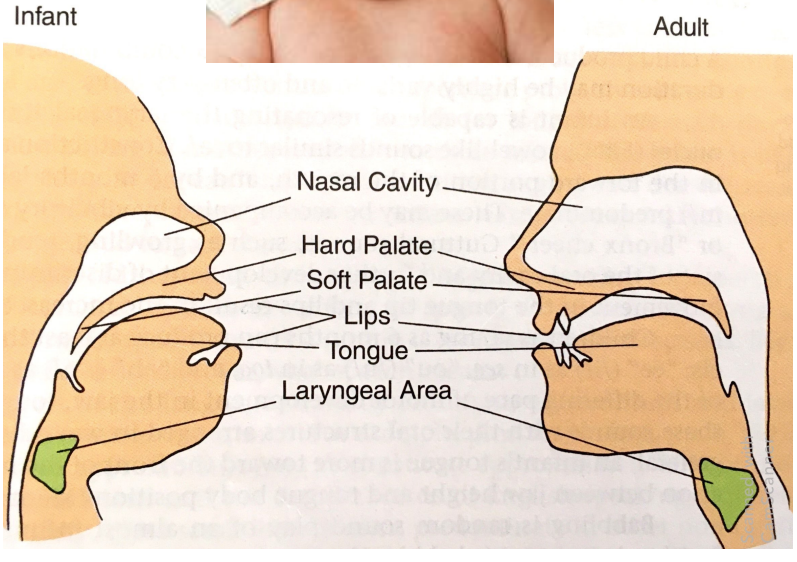
- Before ~9 months of age, little association between vocal behavior and later speech/language abilities
- Starting at about 9 months, vocal behaviors begin to predict later abilities
  - Echolalia
    - Meaningless repetition of adult words
  - Jargon
    - Seemingly meaningful but unintelligible speech
    - Adult-like prosodic and intonation patterns
    - https://www.youtube.com/watch?v=AT-3U3StbSA
  - Phonetically consistent forms (PCFs)
    - Consistent phonetic and prosodic characteristics created and used by the child to represent something
    - The first evidence of a sound-meaning relationship!

Processes underlying speech production development

- Three main factors:
  1. Physical growth & development of the vocal tract
  2. Development of brain systems responsible for motor control of vocal tract and vocalization
  3. Experience

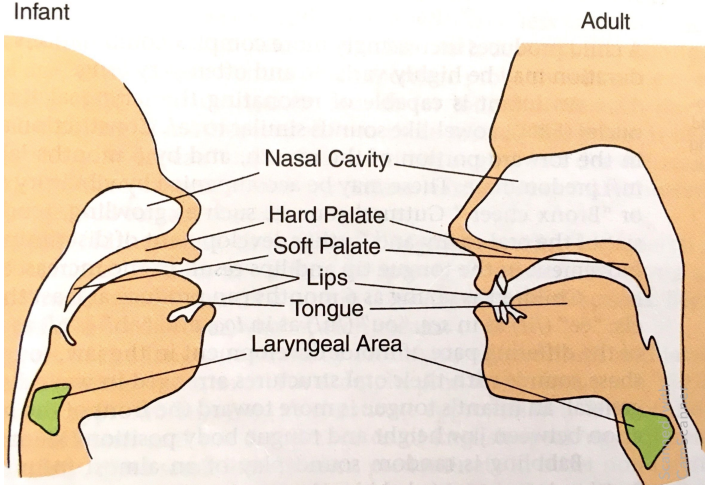
Physical growth & development of the vocal tract

- Newborn vocal tract: smaller & shaped differently from an adult's
  - Tongue fills entire mouth, limits range of motion
  - Larynx position is higher in infants than adults
  - Forces the infant to breathe through the nose
  - Can drink and breathe at the same time !



Physical growth & development of the vocal tract

- Larynx descends by about 3 months of age
  - Allows the tongue to move forwards and backwards
  - Enables production of fuller variety of vowel sounds
- Facial skeleton growth: more room for the tongue
  - New vocal freedom may be a cause of vocal play, allowing new movements that were previously impossible



Oral-Motor Control

- Infants spend more and more time engaging in non-nutritive sucking (4 hours a day at 4 months of age!)
- Oral-motor control begins at the back of the mouth and progresses forward
  - Control over tongue projection ~4-6 months
  - In/out lip control ~6 months
  - Lateral (sideways) tongue control ~8 months
  - Lift tip of tongue ~11 months
  - Keep lips closed when eating and drinking ~11 months
- These motor developments directly influence the sounds that an infant is able to make

Neural Development

- Later neurological developments in higher brain structures correlate with developments in vocalization
  - Maturation of areas in motor/premotor cortex probably required for the onset of canonical babbling
  - Onset of cooing at 6-8 weeks coincides with development of limbic system (including amygdala)
  - These systems are associated with expression of emotion in both humans and other animals

Experience: hearing the speech adults produce

- Hearing adult speech influences the sounds children choose to babble and the prosodic character of later babbling

Experience: hearing the speech adults produce

- Speech heard before six months impacts a child's ability to produce those sounds later
  - Even if the child switches to a completely different language environment afterwards (Choi, Cutler, & Boersma, 2017)
- The amount of time 12-month-olds spend listening to speech is related to vocabulary size at 18 months (Newman et al. 2006)

Experience: hearing the speech adults produce

- Infants increase the complexity of their vocal output when their mother provides immediate social feedback (Goldstein, King, & West 2003)
- 8-month-old infants increase their consonant-vowel vocalizations (canonical & non-canonical babbling) when their mother responds to what she thinks they're saying (Gros-Louis, West, & King 2014)
- Feedback reinforces the behavior (behaviorism) and provides a more complex learning opportunity within the child's zone of proximal development (social constructivism)

Experience: hearing the speech adults produce

- Infants learn foreign language speech sounds much better with a real person interacting with them relative to a passive television broadcast (Kuhl, Tsao, & Liu 2003)
  - Adult second-language learners also seem to pick up sounds more easily when they're engaged socially with the input source

Hearing their own vocal output

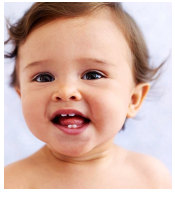
- Babies' first words contain sounds they babbled more than the sounds they hear from adults
- Hearing their own vocal output motivates infant vocalizations
  - Critical feedback for adjusting their productions based on how they sound (Fagan 2014, 2015)
- May help explain why deaf infants have less elaborate vocal play, reach canonical babbling stage later
  - Cochlear implants can help tremendously, though!

Stages of preschool vocal development

0 weeks reflexive crying, biological-based sounds

6-8 weeks cooing

16 weeks vocal play begins



36 weeks reduplicated/canonical babbling

48 weeks nonreduplicated babbling

Recap

- Infants go through different stages of pre-speech production, which allow them to develop the motor skills to produce the speech sounds in their native language

- Development of speech production supported by:
  - Physical growth
  - Neural development
  - Experience

Prelinguistic Speech Perception

Infant hearing

- Fetuses ~8 months old (in the womb) can already process some aspects of speech, particularly prosody (Minai, Gustafson, Fiorentino, Jongman, & Sereno 2017)
  - Fetal heart rates changes when hearing unfamiliar, rhythmically distinct language, Japanese, after having heard a passage of English speech, but not when presented with a second (different) passage of English instead

Infant hearing

- Newborns:
  - Hearing not quite as sensitive as adult hearing, but can hear and process a lot!
  - Middle ear fully developed but filled with fluid, not very sensitive to sound for the first two weeks
  - Prefer passages containing familiar sounds that they were exposed to in the womb

Speech perception & speech production

- Speech production capabilities also seem to impact early speech perception
  - Inhibiting 6-month-old infants' tongue movements reduces their ability to distinguish between speech sounds (Bruderer, Danielson, Kandhadai, & Janet F. Werker, 2015)
  - May reflect additional "training" by repeating speech sounds to themselves (working memory)
  - Or possibility a more direct role of motor speech abilities in supporting speech perception

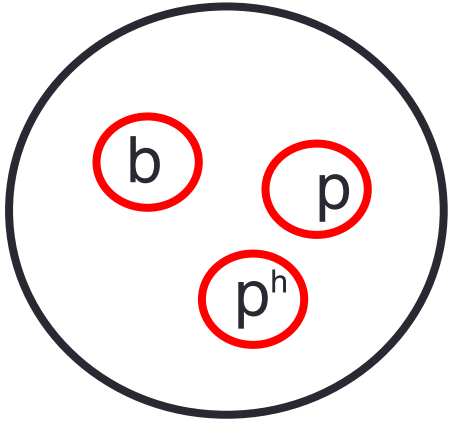
Acquisition of Phonemic Inventory

- Children are born able to discriminate speech sounds from across the world's languages
- Adults CANNOT do this!
  - Infamous example: R & L in native Japanese speakers
  - https://www.youtube.com/watch?v=F4MsJHn-lRA

Acquisition of Phonemic Inventory

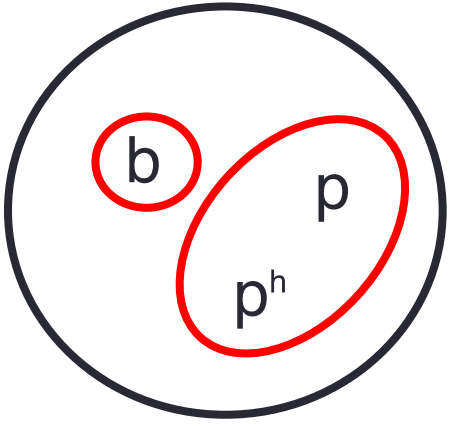
- Acquisition of phonemic inventory (in perception): forming a perceptual *category*
  - Grouping multiple distinct sounds into the same phoneme

Newborns



Newborns can discriminate all of the possible phonemes

Adults



Adults cannot discriminate speech sounds that are not contrastive in their native language

Speech perception in infancy

- Newborns can perceive every phoneme contrast found in human languages
- By 6 months, prefer vowels in native language
- By 8-10 months, perceptual ability limited to native language
  - This reflects the *formation* of phoneme categories

Word segmentation

- How do children even know what is a word?
- /uulʊkɪtsətɔɪ/
- Need to somehow parse out the words from each other!

Word segmentation

- **Phonotactics** and **statistical learning** help
  - Phonotactic constraints: rules against possible phoneme sequences in certain positions of a syllable
  - Affects the probability of co-occurrence of two speech sounds in order
  - Lower phonotactic probability *between* words than *within* words
  - E.g., the word boundaries of **/uu - lʊk - ɪts - ə - tɔɪ/** are more common than **/uul - ʊkɪ - tsət - ɔɪ/**

Word segmentation

- Infants are “little statisticians”, attend to phonotactics
- 5 months:
  - Discriminate their own language from another language with the same prosodic patterns
- 8 months:
  - Learn the phonotactic patterns of speech presented to them (Saffran, Aslin & Newport, 1996; Aslin, Saffran & Newport, 1998)
- 9 months:
  - prefer non-words that comply with the phonotactic probabilities of their native language

Child-Directed Speech

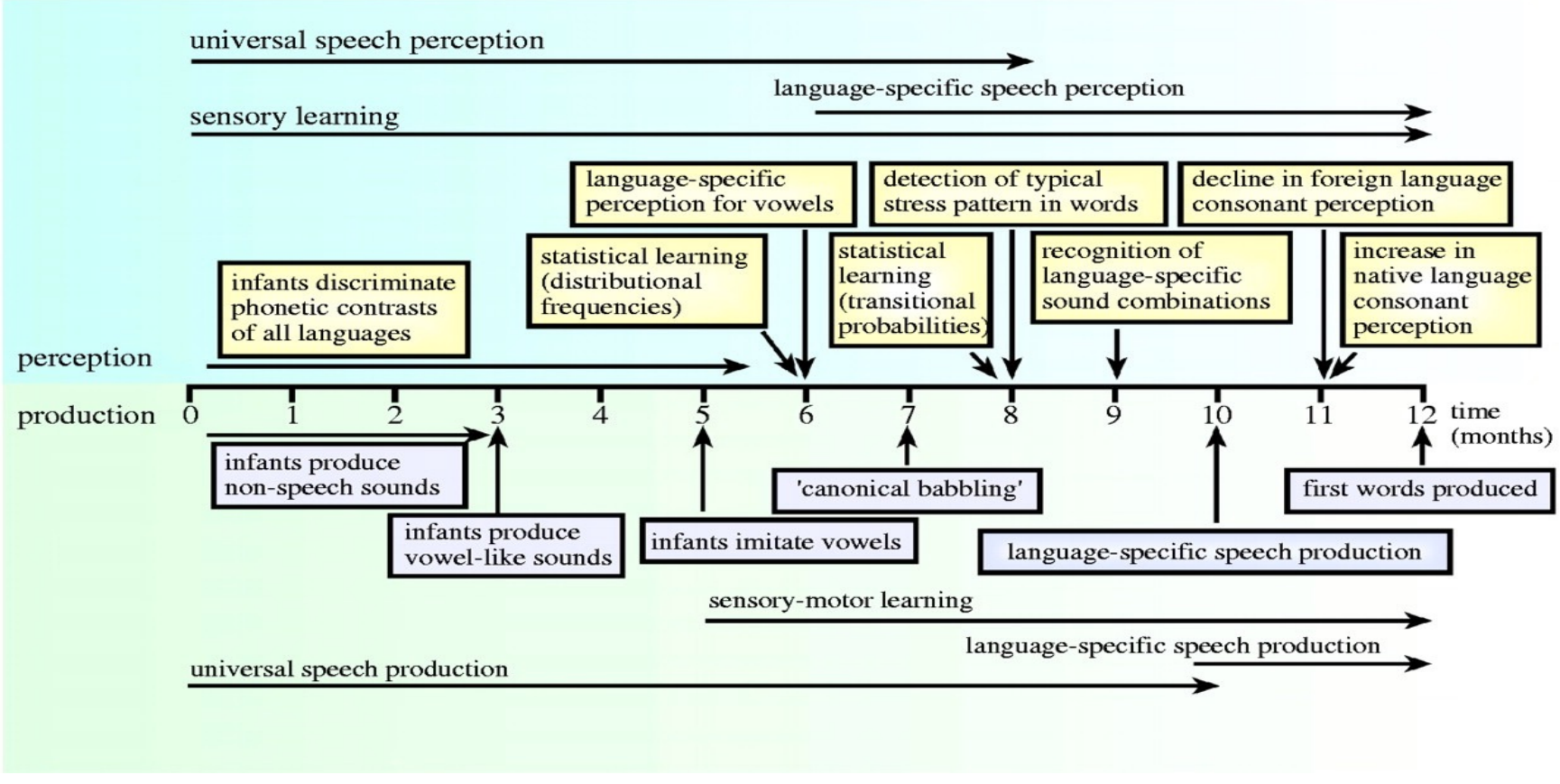
Child-directed speech

- **Motherese/infant-directed speech/child-directed speech**
  - Intonational contour greatly exaggerated
  - Higher-pitched voice, wider range of pitches, longer pauses, shorter phrases, slower tempo (e.g. vowels prolonged)
- Child-directed speech is helpful for language learning:
  - Highlights relevant features of speech sounds
  - Provides clear examples of speech sounds
  - Clearer *differences* among speech sounds
  - The infants of mothers who produce vowels that are more distinct from each other show better speech perception skills
  - Adults learn words in a foreign language better with child-directed speech (Golinkoff & Alioto, 1995)

Benefits of child-directed speech

- Child-directed speech is useful, but not necessary, for language acquisition
  - Not all cultures emphasize it
  - In some cultures (e.g., Samoan, Papua New Guinean, Mayan), it is not appropriate for primary caregivers to *directly* address speech to prelinguistic children

Perception v. Production



Conclusions

- Early motor development:
  - Progresses through several babbling stages
  - Motor development contingent on: physical development, neural development, and language experience

- Early perceptual development:
  - Infants born able to discriminate among a great variety of speech sounds, but lose this ability, which indicates the acquisition of phonemic categories
  - Word segmentation depends in part on statistical learning of phonotactic probabilities
  - Child-directed speech helps