

The littlest language learners: Spotlight on infant speech perception

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Outline

- *Part 1. Speech and what infants bring to the task of speech perception*
 - Why speech perception is so interesting
 - Testing infants' speech perception
 - Prenatal hearing and sensitivity to sound and speech
 - Neonatal auditory preferences
 - Categorical speech perception and perceptual normalisation

- *Part 2: Becoming a language-specific listener*
 - Perceptual reorganization and the language filter
 - Theories/models of perceptual reorganization
 - Speech perception and word learning in the second year of life

Objectives

- *Part 1. Speech and what infants bring to the task of speech perception*
- Learn about challenges of speech perception
- Understand different testing methods
- Knowledgeable of development of hearing *in utero* and sensitivities to speech after birth
- Appreciate didactic role of IDS
- *Part 2: Becoming a language-specific listener*
- Knowledgeable of how the native language shapes speech perception and how the process is different for different populations of infants
- Familiarity with the classic studies of speech perception using a variety of methods
- Consider word learning and speech perception links

PART 1.

*Speech and what infants bring to
the task of speech perception*

Why speech perception is so interesting



Perceiving sound and speech

Burnham & Mattock, in press

- you can't go back and hear again what a person just said
- you don't have to actively orient to sound, and you can't automatically turn your ears off
- Sound waves permeate solid media
- Unlike vision, the system is fully developed in *in utero*

The nature of speech sounds

- Temporal, intensity, and frequency aspects of speech
- Consonants
 - transient energy, and the amplitude of energy is important
 - Voiceless /h/ and /f/ have less energy than /b/ and /g/
 - Narrowband or broadband
 - Some consonants like /b/ and /p/ have release burst, and transition cues

The nature of speech sounds

- Vowels
 - Bands of energy in multiple, relatively infrequent frequency regions (formants)
 - temporal variations in energy bands
- Lexical tone
 - Phonetically identical sound sequences that differ in pitch height, pitch contour, duration and voice quality

*Another reason why speech perception
is so interesting*



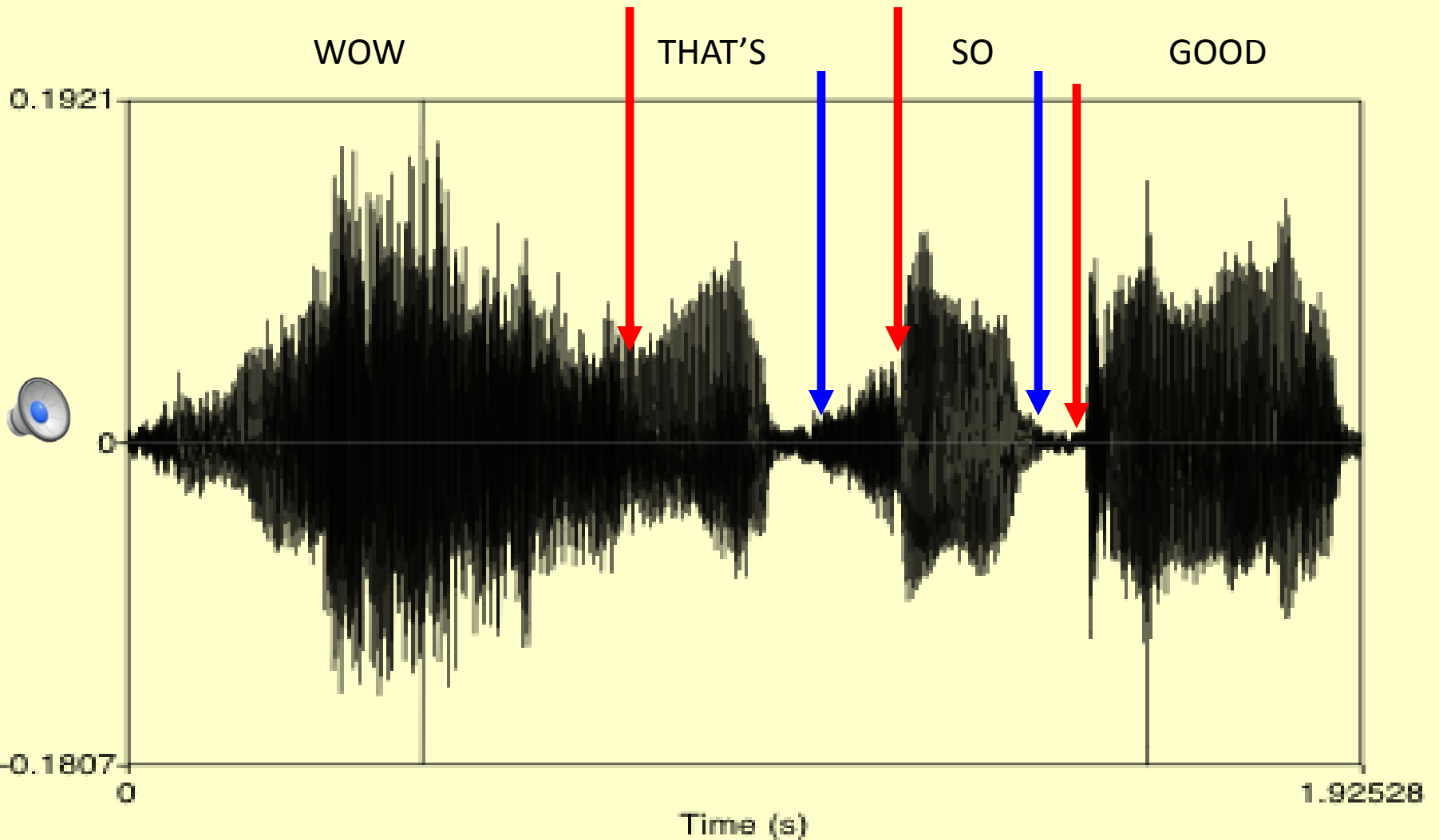
The nature of speech perception

- Observing adults engaged in conversation would suggest that decoding speech is effortless
- Speech perception is made difficult by
 - Invariance problem
 - Talker variability
 - Segmentation problem

The challenges of speech perception

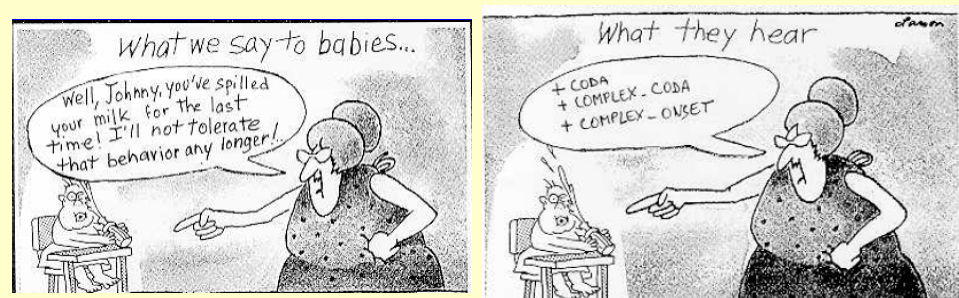
- Invariance problem
 - The same identifiable speech sound can be manifested differently depending on the position of the speech sound in an utterance
 - “tap” vs “pat”
 - “cab” vs. “cap”
- Talker variability
 - How are 2 tokens of a single utterance recognised as the same despite variation acoustic output?
- Segmentation
 - Fluent perceivers of a language hear speech as a sequence of discrete words, despite overlaps

Segmentation problem



To become a fluent perceiver of speech you need to discover...

- what sound units (phones) are in the language
- what phones are relevant for distinguishing meaning (phonemes)
- how to segment words from fluent speech
- permissible ordering of phones (phonotactics)
- relevant rhythmic characteristics (prosody)
- store words



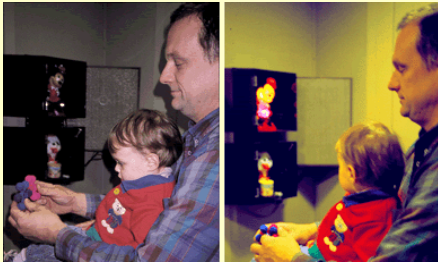
Testing infants' speech perception



Methods

Behavioural

- sucking
- eye movements
- looking time
- head turning



Non-behavioural

- Changes in electrical activity of neurons (EEG, MMN)
- Magnetoencephalography
- Blood flow changes (Near-Infrared spectroscopy)
- Heart rate changes



Behavioural methods



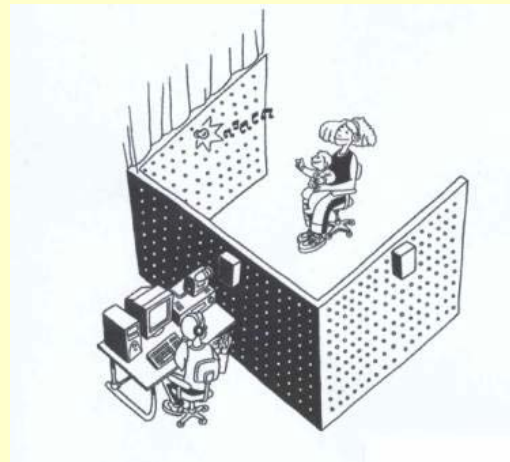
Conditioned head-turn procedure



Habituation procedure



Preference procedure



Head turn preference procedure

Non-behavioural methods



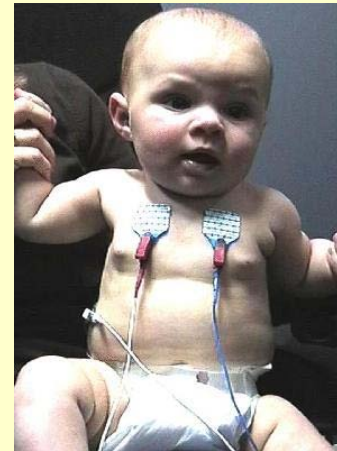
EEG



MEG



NIRS



Heart rate

Thinking about methods

1. What can non-behavioural methods offer that behavioural methods cannot?
 - Is one better than the other?
2. A researcher tests 6-month-olds for discrimination of vowel sounds /a/ vs. /i/ using the conditioned head turn procedure and a MMN task. Infants fail the behavioural task, but showed MMN in response to a change in speech sound.
 - How is this possible?
 - What can the researcher conclude?

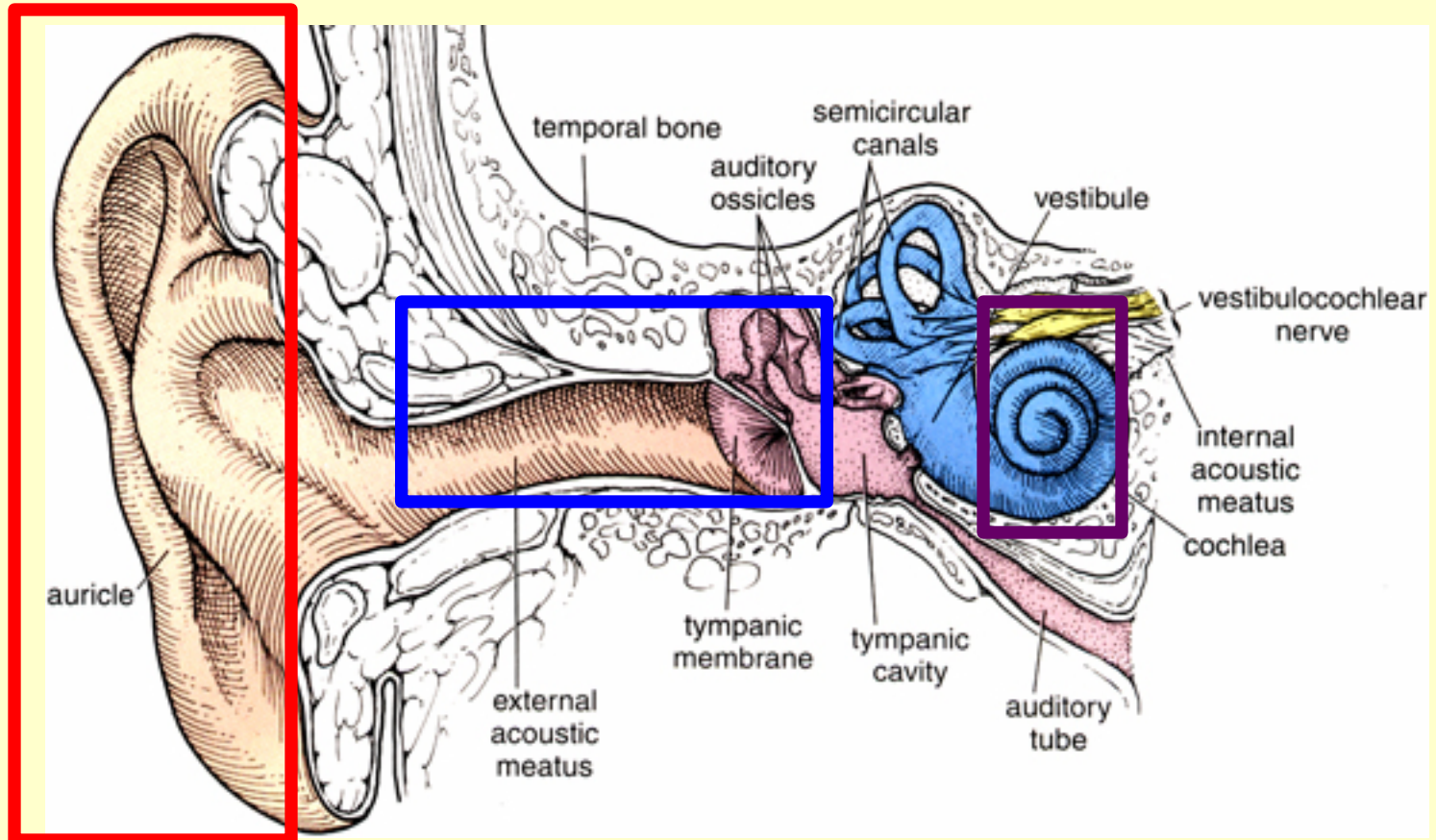
Prenatal hearing and sensitivity to sound & speech



Hearing

- Outer ear is important for localisation; channels sound to eardrum
- Inner ear houses the cochlear and basilar membrane.
 - basilar membrane moves hair cells of cochlear and stimulates nerve impulses to the brain
- The auditory system then calculates what information comes from a common source
 - Sound source segregation

Development of the ear and hearing



Prenatal Hearing?



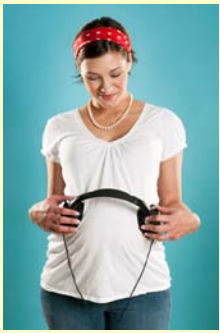
- Yes
- Inner ear becomes more *developed* during second trimester of gestation
- Auditory system is *functional* by the third trimester
 - behavioural responses to sound can be observed from as early as 28 weeks

But what does sound, sound like *in utero*?

Prenatal Hearing

- Prenatal experience with sound is degraded because
 1. Inner ear and auditory nervous system are still developing
 2. Fetus is hearing through fluid (in womb) and tissue; uterine wall attenuates speech signal (low pass filtering)
- Best sound transmitted in utero is mother's speech
- Rhythm and intonation of mother's speech are the acoustic signals that infants have prenatal experience with





Prenatal hearing

- It is possible to measure fetal responses to sound (in utero)
- The fetus responds differentially to sound through changes in heart rate and body movements
 - Recognise mother's voice (Kisilevsky et al, 2003)
 - Discriminate speech sounds (Lecaunet et al., 1987),
 - Discriminate speaker gender (Lecaunet et al., 1993)
 - Sensitive to white noise, frequency and intensity changes in sounds, vibrations

Neonatal auditory preferences



Neonatal auditory preferences

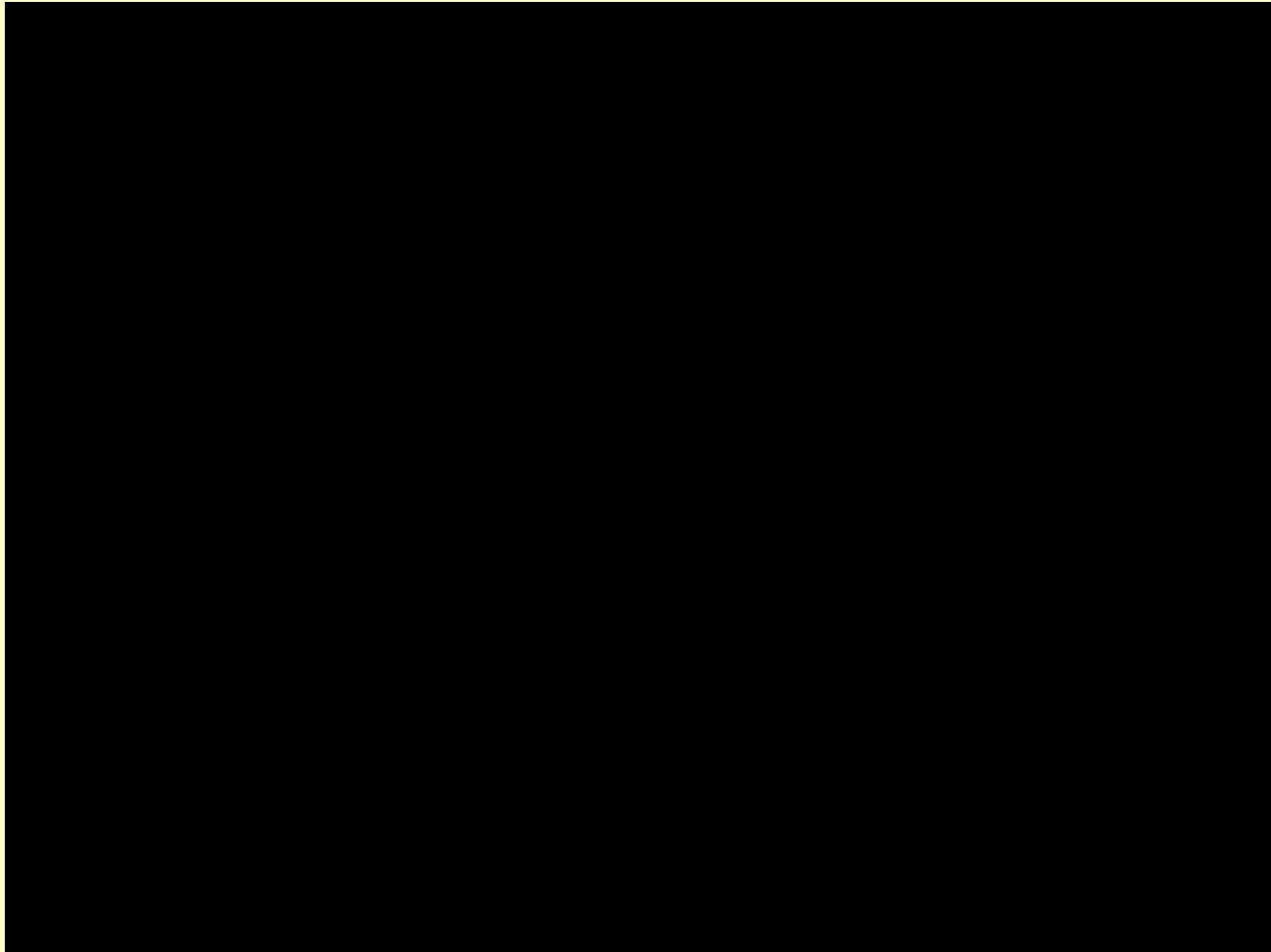


- Infants remember and recognise speech that they heard prenatally
- Implications
 - Are infants hard-wired for language? (Chomsky)
 - Prenatal experience plays a critical role in priming infants to attend preferentially to acoustic signals with the pitch and rhythm of human voices

Measuring neonatal auditory preferences

- High Amplitude Sucking Procedure (HAS)
 - Pacifier attached to pressure transducer which measures sucking rate - strength of the infants sucks
 - Establish baseline sucking rate
 - Present auditory stimulus whenever the baby gives a high amplitude suck
 - Baby learns that their sucking is contingent on presentation of the auditory stimulus
 - Infants suck more strongly and for longer duration to auditory stimuli they prefer

Measuring neonatal auditory preferences



Neonatal auditory preferences: Speech

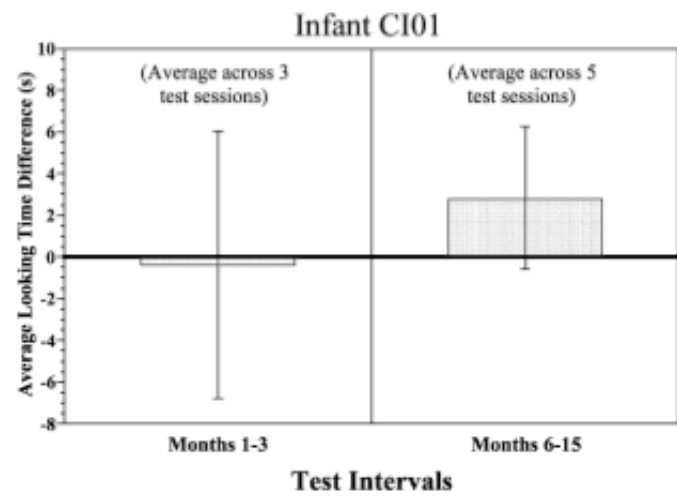
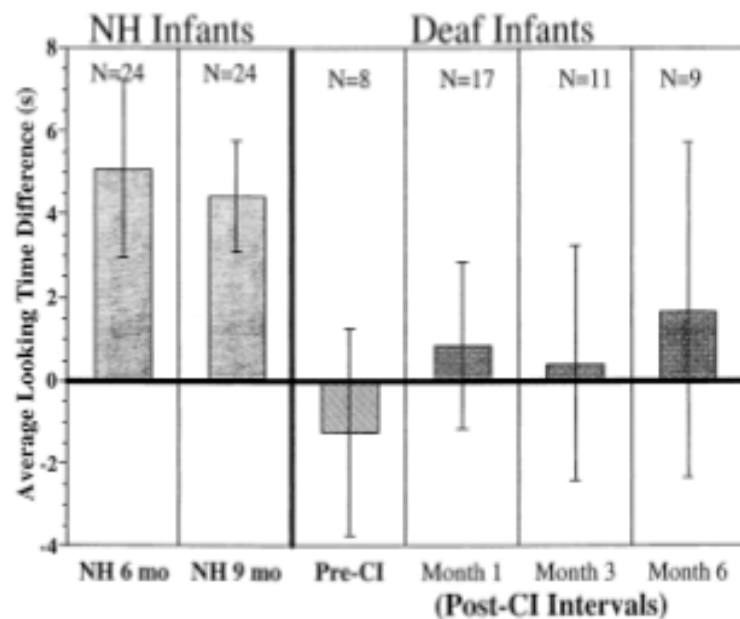
- Preference for speech over filtered speech
(Spence & DeCasper, 1987)
- Preference for speech over reversed speech
(Pena et al., 2003)
- Preference for speech over complex synthetic sounds and white noise (Vouloumanos & Werker, 2007)
- **Speech is special** (Liberman & Whalen, 2000; Pinker & Jackendoff, 2005)

Neonatal auditory preferences: Speech

- Neonates speech preference may derive from properties of speech that are not shared with the vocalizations of other species.
- Vouloumanos et al. (2010)
 - Neonates have equal preference for speech and rhesus macaque vocalisations
 - 3-month-olds preferred human speech
 - listening preferences are sharpened over first months of life, yielding a species-specific preference for speech

Auditory preferences in hearing impaired infants: Speech

- Infants with cochlear implants
 - Infants cochlear implants do not prefer speech over silence (Houston et al, 2003)



Neonatal auditory preferences: Native language

- Moon, Cooper, & Fifer (1993)
 - Newborns born to Spanish- or English-speaking mothers
 - Spanish and English have different rhythmic cues
 - High-amplitude sucking, infant-controlled
- Infants produced the sucking response that allowed access to their native language

Neonatal auditory preferences: Native language

- Infants language discrimination abilities at birth improve rapidly over the first 6 months of life
 - Originally discriminate languages only if the languages are from different rhythmic classes
 - By 6 months infants discriminate languages that are within rhythm class (See Mehler et al, 1988; Hayashi et al, 2001)

Neonatal auditory preferences: Native language

- Bilingual infants are similar to their monolingual peers in their language discrimination competency
- Bilinguals differ from their monolingual peers in how they attend to language differences
 - bilinguals oriented slower to their native language than monolinguals

(Spanish/Catalan: Bosch & Sebastian- Galles, 1997; 2001)

Neonatal auditory preferences: Mother's voice

- DeCasper & Fifer (1980)
 - HAS procedure: baseline sucking first
 - Mother's voice and voice of female stranger
 - Sucking bursts greater than baseline produced one voice, sucking bursts less than baseline produced other voice
 - Neonates sucked most often with the burst rate that produced their mothers voice


Neonatal auditory preferences: Mother's voice

- Newborns show no preference for father's voice over voice of another male (DeCasper & Prescott, 1984)
 - Father's voice not as audible in utero
 - Father may not be recognised as easily through auditory cues
- Lack of preference for dad's voice still not present at 4 months (Panneton Cooper & Ward, 1999).

Neonatal auditory preferences: Stories

- Preference for stories heard prenatally (DeCasper & Spence, 1986)
- Pregnant women read stories to their infants for 6 weeks prior to birth
 - Newborns were given a choice of what story to listen too
 - Preferred familiar story as measured using HAS
- Infants remembered *something* about the acoustic cues of the target passage.

Neonatal auditory preferences: Infant-directed speech

- Adults, particularly mothers, modify their speech to infants
 - Evident in many cultures 
 - “Unconscious” modification of register
- What are some of the characteristics of IDS?
 - hyperarticulated vowels, higher pitch, exaggerated pitch and prosody, use of repetition, high emotion, slow rate

Neonatal auditory preferences: Infant-directed speech

- Two-day-old infants and 1-month-old infants prefer looking at a visual stimulus when looking produces a recording of speech in an infant-directed style than a recording in an adult-directed style (Cooper & Aslin, 1990)
- Infants' preference for the exaggerated prosodic features of ID speech is present from birth and may not depend on any specific postnatal experience.

Neonatal auditory preferences: Infant-directed speech

- **Maintains attention** (Fernald & Simon, 1994; Stern, Spiker & MacKain, 1982)
- **Communicates emotion and facilitates social interaction** (Fernald, 1989; 1992; Werker & MacLeod, 1989)
- **Facilitates language acquisition** (Fernald & Mazzie, 1991; Burnham, Kitamura & Vollmer Conna, 2002)
- **Infants prefer to listen to infant-directed speech**
 - Preference holds from infants as young as a few days old up to one year (Cooper & Aslin, 1990; Fernald, 1985; Pegg, Werker, & McLeod, 1992; Werker & McLeod, 1990)

What features of IDS do infants prefer?

- Is perceived emotion in speech enhanced (or not) by duration? (Panneton, Kitamura, Mattock, & Burnham, 2006)
 - 18- & 32- week-old infants
 - high or low affect condition; slow speech rate or fast speech rate condition; combination conditions
 - 18-week-olds attended most to slow IDS and high affect conditions
 - 32-week-olds attended more to normal rate IDS (re of affect).

Does infant-directed speech serve a didactic function?

- Infant-directed speech serves a linguistic function...
 - Vowels are very ‘stretched’, “eee”, “ooo” and “aah”
- Unconsciously use IDS to help language learning
 - Good test...pet-directed speech
- Burnham, Kitamura, & Vollmer-Conna, 2002
 - Use of pitch, affect, and vowel hyperarticulation in infant-, adult- and pet-(dog)directed speech
 - Mothers were recorded speaking to their baby, an adult, and a pet with a toy “sheep”, “shoe” and “shark”

Does infant-directed speech serve a didactic function?



- Adult-directed speech was different on all accounts
- Pet-directed and infant-directed speech were matched on pitch and affect
- Only infant-directed speech had hyperarticulation

Does infant-directed speech serve a didactic function?

- infant-directed facial expressions (Chong & Werker, 2003)



Figure 1. An example of expressions A, B, and C in Rows 1, 2, and 3, respectively, from two English-speaking and two Chinese-speaking mothers.

Thinking about neonatal auditory preferences

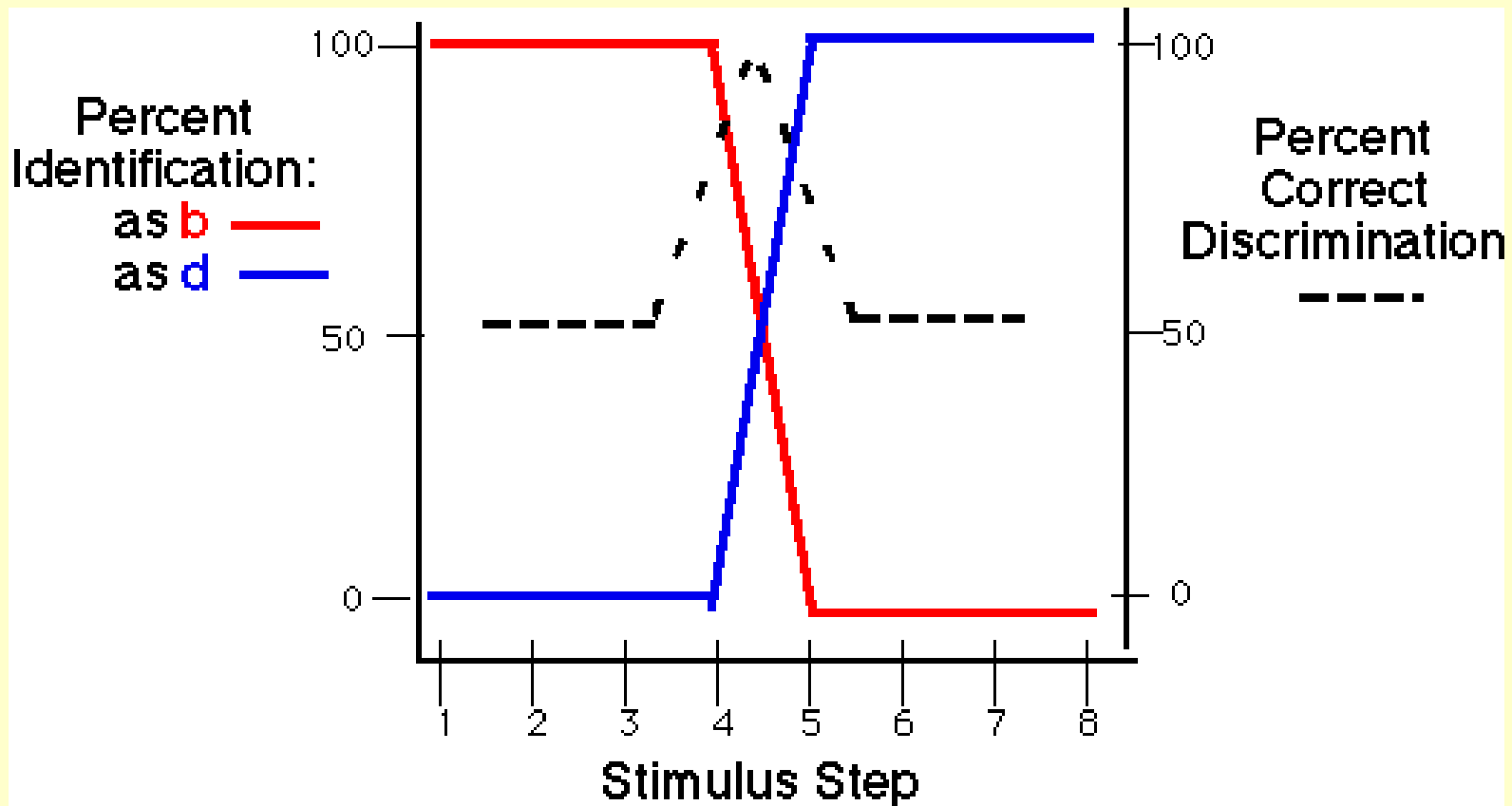
1. How might infants' early sensitivities to the global properties of language be important for later language development?
2. Can infants' early sensitivities be taken as evidence that infants are hard-wired for language?

Categorical speech perception & perceptual normalisation



The first studies of infants' speech perception

- Categorical speech perception
 - Speech sounds varying along a continuum are perceived to belong to discrete categories
 - Discrimination and identification of tokens at the boundaries of the categories is better than discrimination and identification of tokens within categories
 - Continuum is created by altering the acoustic dimension of interest in small equal steps.
 - Consonants categorically perceived, vowels continuously perceived, speech vs non-speech, boundaries are influenced by native language
- see <http://www.ling.gu.se/~anders/KatPer/Applet/index.eng.html>



The first studies of infants' speech perception

- It was initially thought that categorical perception was something learned through experience perceiving and producing speech
- Chomsky (1965)
 - Raised the idea that linguistic abilities have an innate rather than experiential bias
 - He argued that categorical perception was innate linguistic endowment

The first studies of infants' speech perception

- Eimas et al., (1971)
 - 1- and 4-month-olds
 - High amplitude sucking procedure
 - ba-pa distinction
 - Infants showed good between-category discrimination; poor within-category discrimination
 - No identification function...
 - Conclusions
 - Very young infants can discriminate speech sound contrasts
 - Categorical perception, like adults
 - Experience is not a pre-requisite
 - Part of innate biological endowment (?)

Perceptual normalization

- Infants do cope with the challenges of speech perception
- Multiple talkers
 - 6-month-old can discriminate vowels when there are multiple talkers (Kuhl, 1983)
 - 2-month-olds can discriminate consonants when multiple talkers (Jusczyk et al., 1992)

Perceptual normalization

- Token variability (Jusczyk et al., 1992)
 - 12 tokens of “bug” vs. “dug”
presented produced by same talker
 - 2-month-old Infants detected the
change in speech sound
- Infants can segment (Jusczyk & Aslin, 1995)
 - recognise sound patterns of words from
passages when presented in isolation

Segmenting speech: A hierarchy of cues

Mattys et al., 2005

- Tier 1, Lexical.
 - Lexical knowledge
- Tier 2, Segmental.
 - *Phonotactics* permissible sequences of phones; regularities in speech that help to define word boundaries, (e.g. “mt”, “ng”)
 - *Acoustic-phonetics* sounds in context, e.g. coarticulation or allophony
- Tier 3, Metrical Prosody.
 - stress patterns cues variations in amplitude, fundamental frequency (F0), and syllable duration.



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The story so far

- There are a variety of complementary methods for testing infants' speech perception
- Infants' early sensitivities are driven by prenatal auditory experience and likely assist language learning
- Infants cope remarkably well with the challenges of speech perception
- Infant-directed speech is an important tool for maintaining attention, communicating emotion and has a didactic function

PART 2.

Becoming a language-specific listener



Perceptual reorganization and the language filter



Developing native language speech perception

- Complex interaction between the child and their language environment
- Infant plays an active role in abstracting linguistic knowledge (intake) from the input
- Many factors affect typical speech perception development in infancy, both positively or negatively.

Constraints on the development of speech perception

- What language you are hearing
- Learning more than one language
- Hearing impairment
- Otitis media with effusion (middle ear infection with fluid)
- Rich vs. impoverished language environment

Approaches to studying infant speech perception

- Ontogenetic method
 - Across ages, same language experience
- Differential Experience method
 - Across language, same ages
- Ontogenetic + differential experience method
 - combined

Developing native language speech perception

- Early investigations showed that infants can discriminate speech contrasts they haven't heard before (eg. Lasky et al., 1975; Trehub, 1976)
 - Adults cannot
- Infants begin with a language-general capacity
 - They can discriminate differences between any 2 speech sounds from any of the world's languages
- Infants develop language-specific speech perception by “honing in” on speech contrasts in their native language

Developmental changes in speech perception

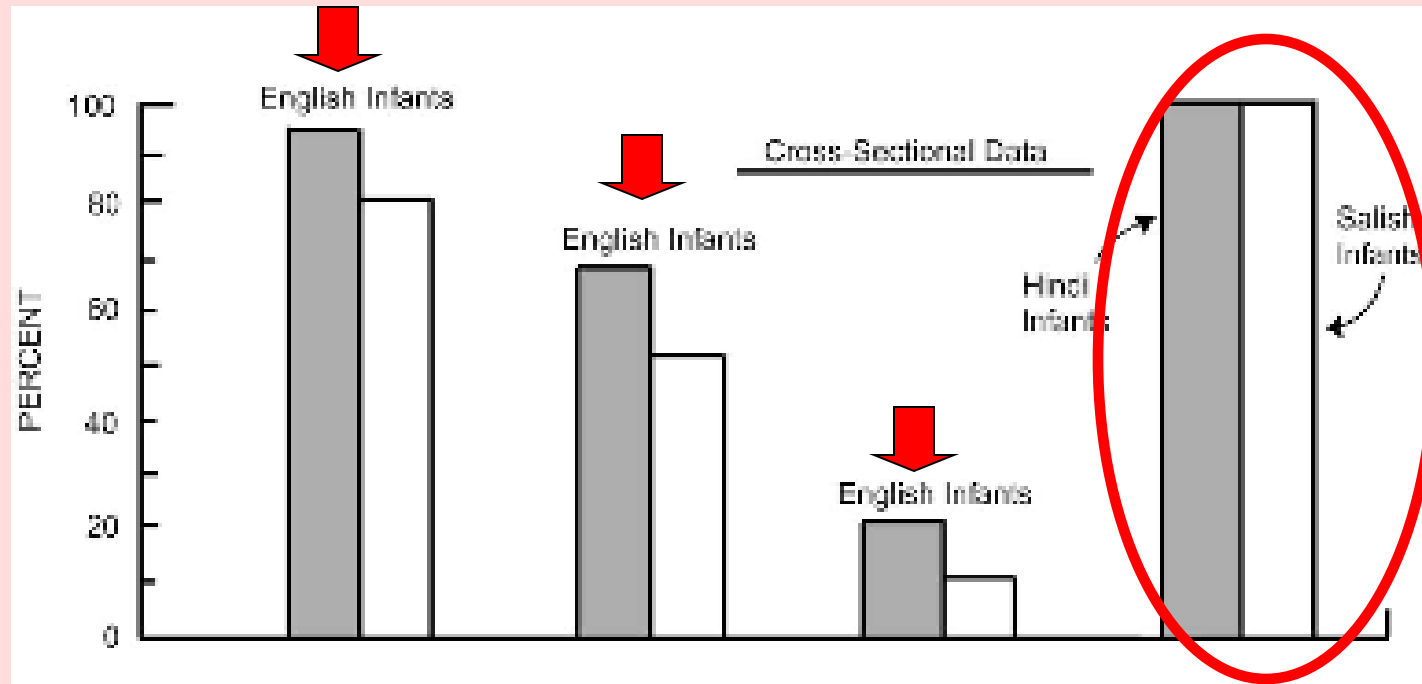
Werker & Tees (1984)

- When does sensitivity to nonnative contrasts decline?
- English-learning infants of 6-8months, 8-10 months and 10-12 months; Hindi- and Salish-learning infants
- Consonant contrasts from Hindi and Salish
- Conditioned head-turn procedure
 - Infants heard repeating background sound and were trained to turn their head to a visual reinforcer when there was a change in speech sound category

Werker & Tees (1984)



The percentage of infants that discriminated the contrasts



Legend: Hindi Salish

Progressive age-related decline (from 6 MONTHS) in discrimination of the nonnative contrasts for English infants

Implication of Werker & Tees (1984)

- Progression from language-general mode to a language-specific mode of processing speech sounds
 - Age, linguistic experience, changing brain
- “Perceptual loss”
 - Use it or lose it!
- “Perceptual reorganization”
 - Attentional loss - “filter analogy”
 - Discrimination of nonnative contrasts (adults) improves with training (Werker & Logan, 1988 and many others)



Perceptual reorganization for other speech sounds

VOWELS

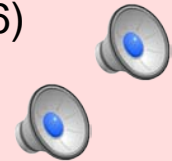
English infants' discrimination of German vowel contrasts **declined** from 4 months - earlier than for consonants!

(Polka & Werker, 1994)

TONES

English infants' discrimination of lexical tone **declined** between 6 and 9 months

(Mattock & Burnham, 2006)



NONNATIVE

English infants' discrimination of native "d" -"th" **equivalent** at 6-8 and 10-12 months, adults **improved**

(Polka, Sundara, & Colantonio, 2001)

Chinese infants' discrimination of native lexical tone was **equivalent** at 6 and 9 months of age

(Mattock & Burnham, 2006)

NATIVE

Using MMN to measure perceptual reorganization

Cheour et al., 1998

- Finnish infants, 6 and 12 months
- Estonian infants, 12 months
- Two contrasts: One vowel pair (Finnish & Estonian); one vowel pair from Estonian
- Hypothesis:
 - 6-month-old Finnish : MMN to Finnish/Estonian and Estonian -only vowel pair (language-general)
 - 12 month-old Finnish : MMN to Finnish/Estonian vowel pair but not Estonian-only
 - 12-month-old Estonian: MMN to both vowel pairs (both are native)



Using MMN to measure perceptual reorganization

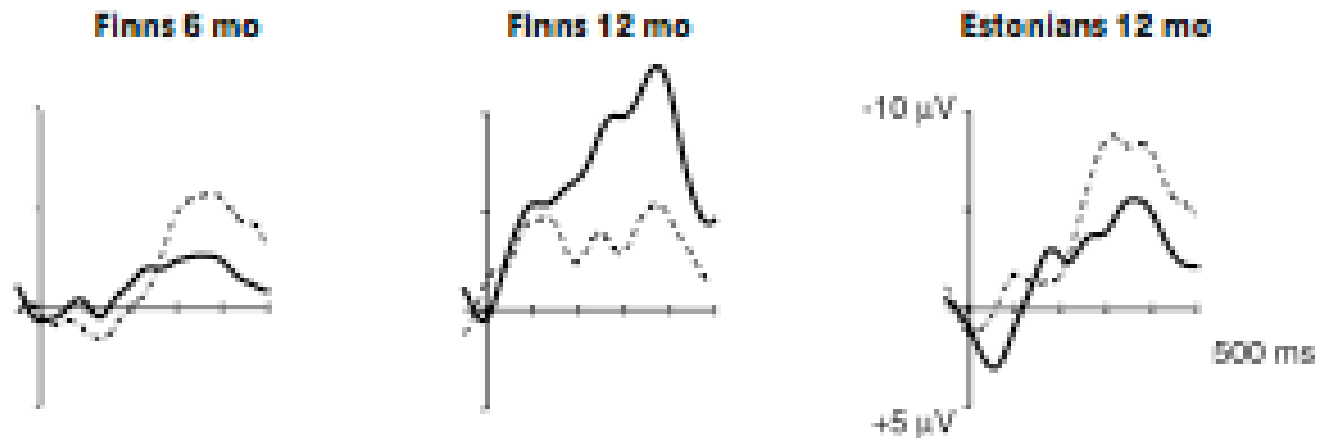



Fig. 2. The MMN amplitude at the central Cz electrode (grand-average, deviant-standard difference waveform, averaged across nine infants) reflects the development of language-specific memory traces in Finnish infants. At six months of age, their MMN amplitude reflects only the acoustical difference between the deviant and standard stimuli. In contrast, at one year of age, the MMN amplitude in the same children was considerably enhanced for the Finnish vowel /*ö*/ and considerably attenuated for the Estonian vowel /*õ*/. In Estonian one-year-old infants, the MMN amplitude reflected only the acoustic difference between deviant and standard stimuli, as both deviant stimuli are vowels in Estonian. — standard /*e*/ - deviant /*ö*/, a vowel shared by Finnish and Estonian languages, - - - standard /*e*/ - deviant /*õ*/, an Estonian vowel.

Perceptual reorganization for other features of speech

- Over age and with increasing experience with the native language infants become increasingly sensitive to other features
 - Native language prosody (Morgan, 1996)
 - Native language stress patterns (Turk, Jusczyk, & Gerken, 1995; Jusczyk, Cutler & Redanz, 1993)
 - Native language phonotactic (Friederici & Wessels, 1993)

Perceptual decline does not occur for all nonnative contrasts

- **Zulu clicks** (Best, McRoberts, & Sithole, 1988)
 - Good discrimination by English-learning infants across age, and adults
 - Native language filter emerging in infancy is *domain-specific*.
- **Non-speech tone** (Mattock & Burnham, 2006) 
 - No decline in discrimination with age for English infants
 - Native language filter emerging in infancy is *functionally-specific*

*To hear some clicks

<http://hctv.humnet.ucla.edu/departments/linguistics/VowelsandConsonants/course/chapter6/zulu/zulu.html>

Perceptual decline occurs for some native contrasts

- An age-related decline in discrimination in infancy has also been found for a native phonetic contrast
 - English-learning infants' discrimination of the native /s–z/ (Best & McRoberts, 2003).
- Some phonetic differences are less salient than others irrespective of language experience

Perceptual reorganization in bilingual infants

Bosch and Sebastián-Gallés (2003a)

- Spanish, Catalan, bilingual infants of 4, 8, 12 months
 - /ε–e/ vowel contrast; native in Catalan, nonnative in Spanish
- Findings
 - Catalan infants (4 = 8 = 12)
 - Spanish infants (4 > 8 = 12)
 - Bilingual infants 4 > 8 < 12
- Pattern also found in studies of consonant perception (Bosch & Sebastián-Gallés, 2003b; Burns, Werker, & McVie, 2003).

Why a U-shape pattern for bilinguals?

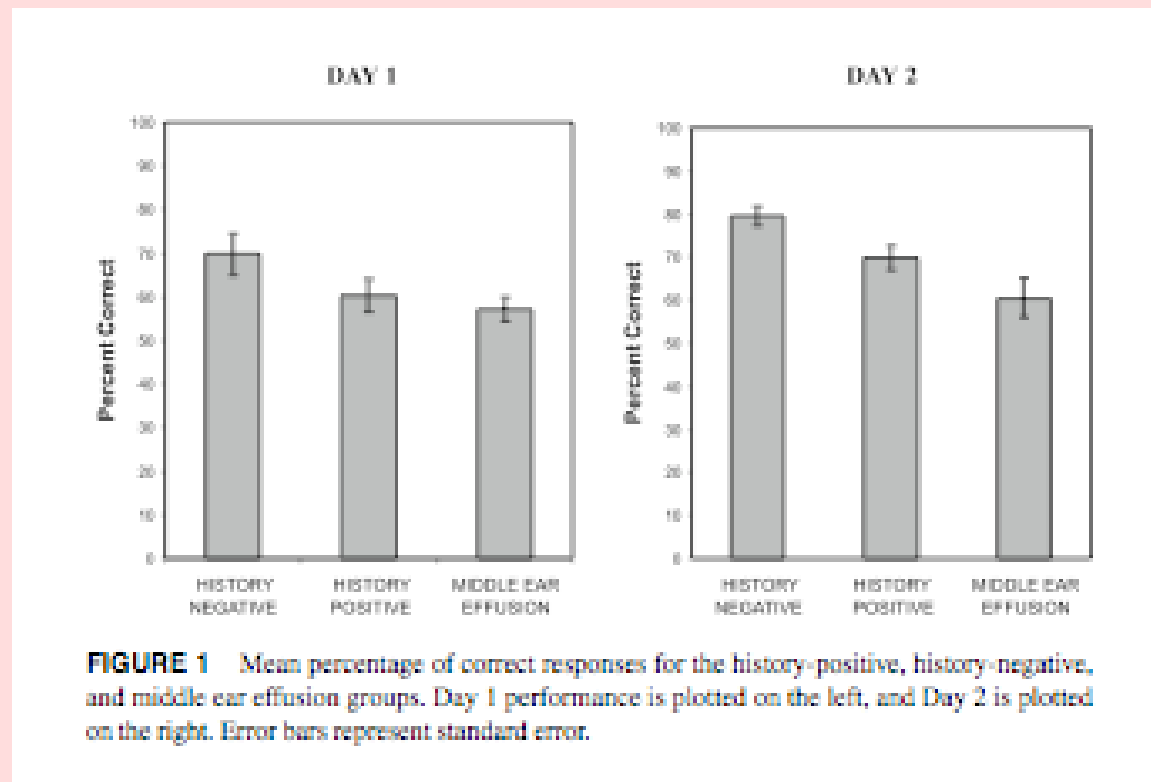
- The phonetic contrast has conflicting status across the bilinguals' two languages
 - native in one; non-native in the other.
 - reduced exposure to such contrasts in the bilingual input
 - Bilinguals may first focus on the contrasts that are common to both their languages → adaptive strategy
- More appropriate to test bilinguals on contrasts that are functional in both languages

Thinking about perceptual reorganization

1. Polka et al. (2007) use the analogy of a 'language filter' to explain the development of speech perception. How does the language filter operate for i) native and nonnative speech sounds, and ii) infants learning one vs two languages?
2. Experience with the native language alone does not guarantee that language-specific speech perception will develop at the same age, or in the same way, for all infants. What other factors could negatively impact infants' intake of linguistic input, and how might problems be overcome?

Perceptual reorganization in infants with otitis media with effusion

- Middle ear infection with fluid
- Fluid leads to mild conductive hearing loss



Thinking about the influence of ear infections on speech perception

1. Should researchers investigating infants' speech perception screen for ear infections and omit data from infants with middle ear fluid?
2. What strategies can you think of that parents/caregivers could employ to optimise language input to infants with recurrent ear infections?

Theories/models of perceptual reorganization



What is driving perceptual reorganization?

Models of perceptual development (Aslin & Pisoni, 1980)

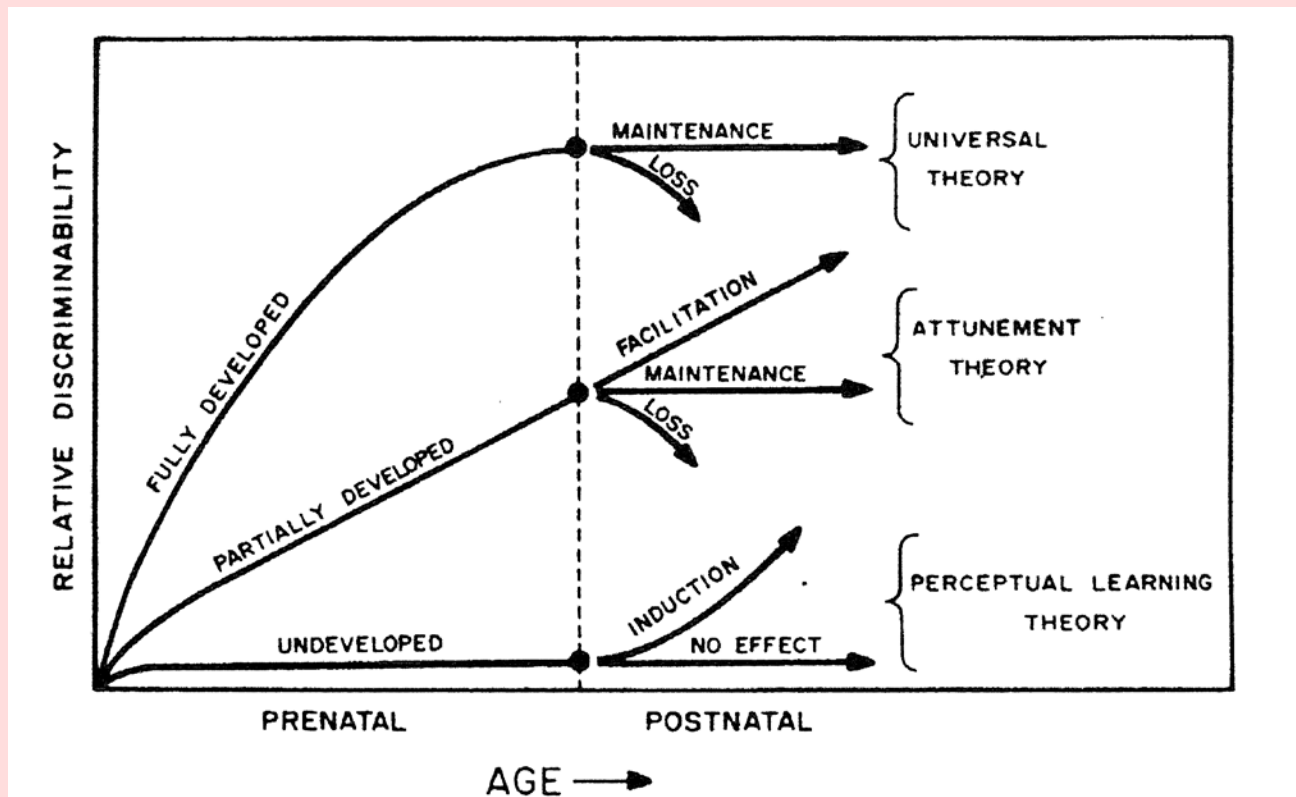


Figure 2.2. Models of perceptual development: Universal Theory, Attunement Theory and Perceptual Learning Theory, originally published in Aslin and Pisoni (1980).

What is driving perceptual reorganization?

- Perceptual Assimilation Model (PAM, Best, 1994; 1995)
- Consonants
- Direct-realist view
- Infants initially perceive only non-linguistic information in speech, such as vocal gestures
- Increased attention to acoustic information and gestures leads to language-specific speech perception
- Whether nonnative speech sounds are discriminated relates to similarity/dissimilarity with native phones

What is driving perceptual reorganization?

- Native-language magnet theory (Kuhl & Iverson, 1995)
- Phase 1: At birth infants separate sound stream into innately specified categories based on general auditory perception
- Phase 2: From experiencing consonant and vowel sounds infants develop language specific boundaries -
→ magnet effects
- Phase 3: nonnative phonetic boundaries are erased and infants' perceptual system reorganized by language-specific categories – magnets
- New addition: neural commitment

What is driving perceptual reorganization?

- DRIBBLER (Morgan et al., 2003; Anderson et al., 2003)
- Statistical learning account of speech sound discrimination
- Infants consider the overall frequency of phonetic features and lose the ability to discriminate nonnative sounds
- Nonnative sounds gravitates to similar native category. More frequent sounds cluster earlier and more densely than less frequent sounds
- nonnative low frequency sounds are less likely to cluster with native sounds and may be considered a new category and reorganized later

The story so far...

- Infants display an impressive array of abilities to discriminate speech sounds
- By the end of the first year of life they are showing abilities that optimal for learning the native language
- Is there continuity between speech perception in the first year of life and word learning in the second year of life?

*Word learning in the second
year of life*

What's involved in learning the names of objects?

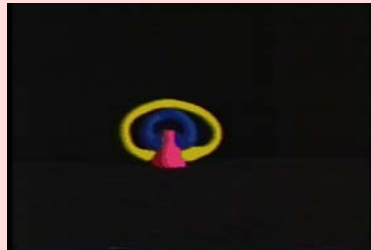
- Access the relevant phonetic units in the speech signal
- Recognize two visual patterns as distinct whole objects
- Hold both types of information in memory long enough to link each phonetic string to the appropriate object without any additional contextual cues to support this mapping.

Switch task



Pre-test,
post-test

Habituation

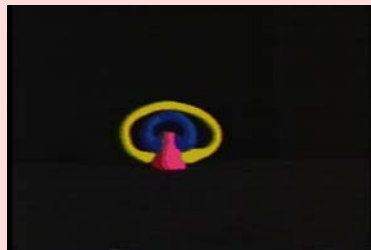


“bih”

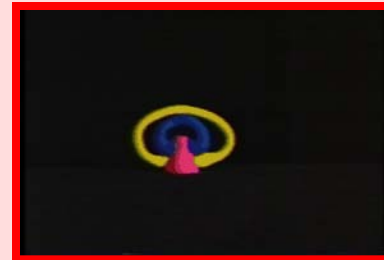


“dih”

Test



same “bih”



switch “dih”

Infants' word learning

- Infants' don't always use their speech perception abilities in word learning task (Stager & Werker, 1997)
 - 14-month-old failed when “bih” and “dih” were used
 - 14-month-olds succeeded with “lif” and “neem”
 - 8-month-olds succeeded with “bih” and “dih”
- Why did the 14-month-olds fail ?
 - 8- and 14-month-olds treat task differently
 - Processing cost is speech sound detail
- By 17 months, no problems (Werker et al., 1992)
 - Individual differences related to productive vocabulary size (+ or - 25 words)

Continuity between speech perception and word learning

Werker et al 2004, 2005a, 2005b

- Continuity between pre- and post lexical representations?
- Infant's ability to discriminate speech sounds is maintained across development but cannot always be accessed
- Cognitive demands of word learning limits 14-month olds' ability to make word-object mappings
- By 17 months (and with increases in vocabulary) infants succeed

Word learning in bilingual infants

- Word-object associative learning may be more challenging for bilinguals
 - Bilinguals need to activate and use only the phonetic detail that is appropriate to the language they are hearing
 - Phonetic category development ‘delayed’ in bilinguals

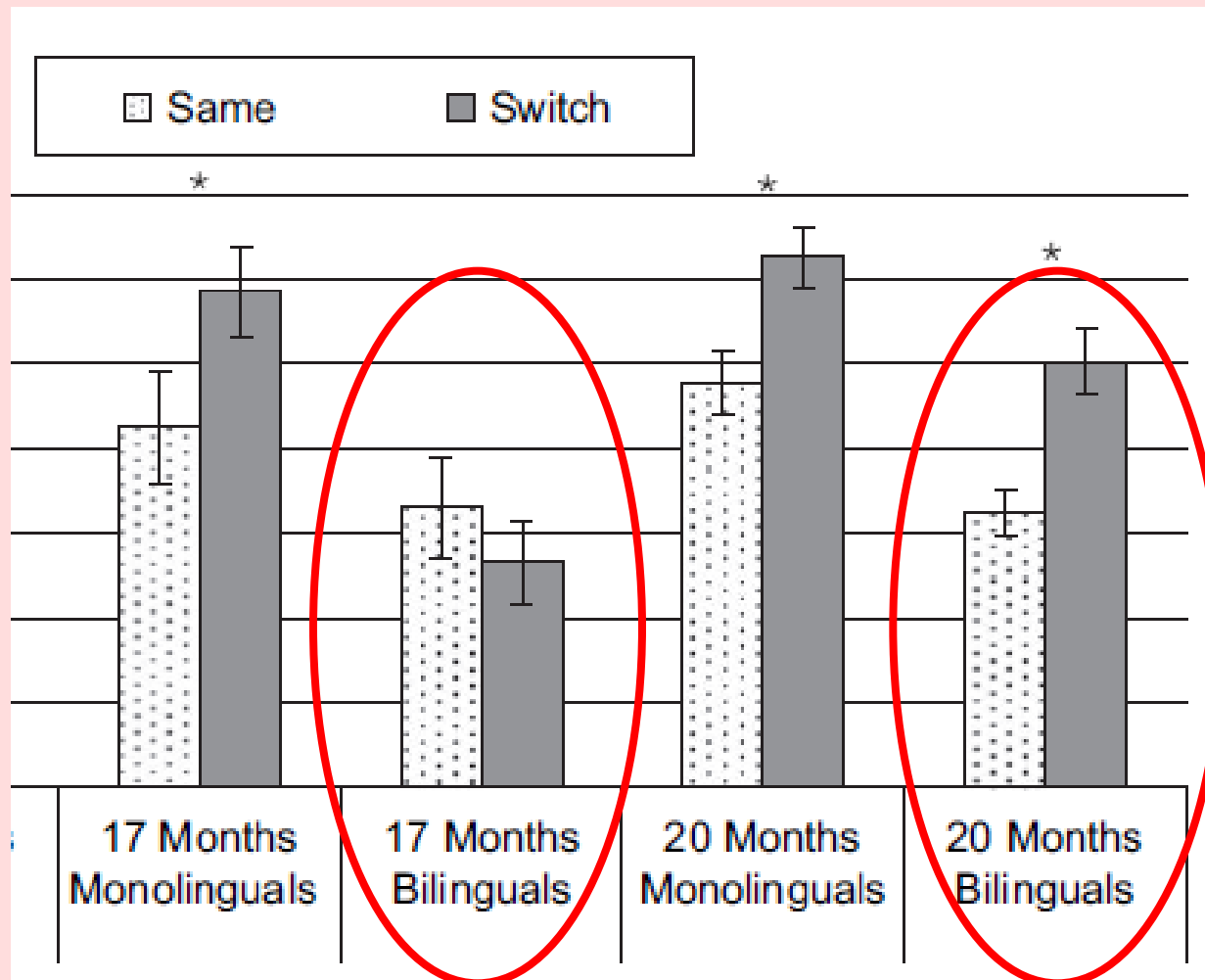
Word learning in bilingual infants

- The nature of bilingual input means more speech sounds and object labels to learn
- Two separate lexicons and phonetic systems, one for each language? (e.g., Paradis & Genesee, 1996)
- one lexicon/phonetic system ?(e.g., Volterra & Taeschner, 1978).
- Delays in word learning?
 - However, bilingual infants have vocabulary sizes similar to those of monolinguals of same age (e.g., Pearson & Fernandez, 1994; Petitto et al., 2001)

Using speech sounds to guide word learning

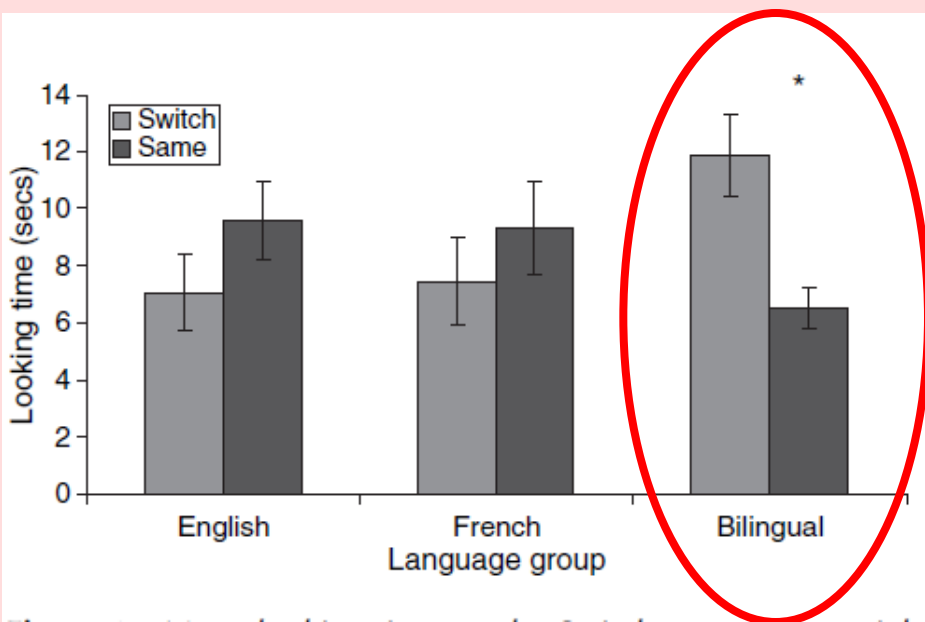
Fennell et al., 2007

“bih” and “dih”

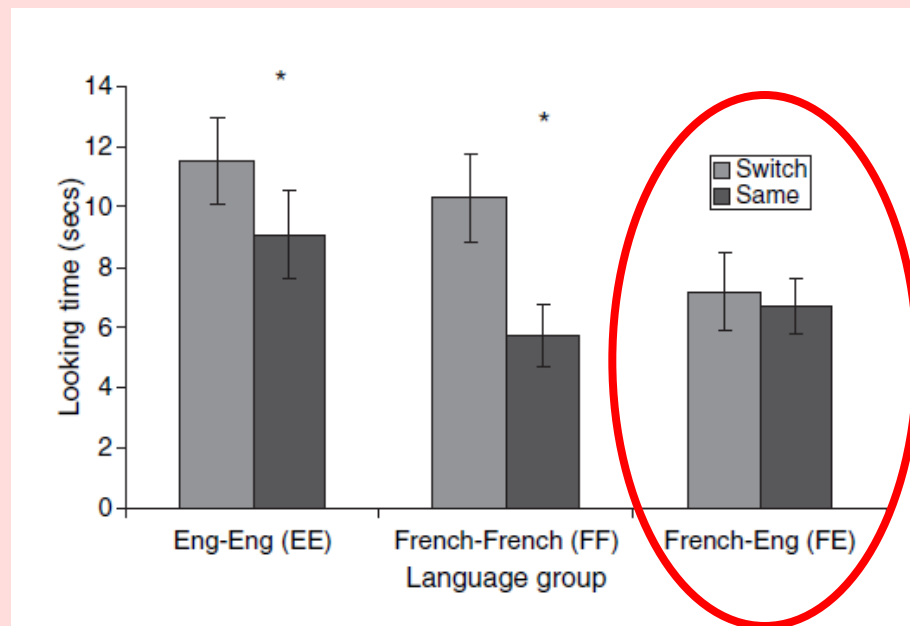


Using speech sounds to guide word learning

Mattock et al., 2010



Bilingual “bos” and “gos”



Monolingual “bos” and “gos”

Thinking about equating tasks demands for monolinguals and bilinguals

1. Can you think of another experiment that will sufficiently test the speech perception/word learning skills of monolingual vs. bilingual infants and be equivalent in cognitive demands?

Summary

- Infants' speech perception is shaped by the ambient language(s) through perceptual reorganization
 - Language filter is active
- Perceptual reorganization and word learning follows a different developmental course for monolingual and bilingual infants
- Continuity between speech perception and word learning is dependent on task demands

Thinking about future directions

- Where do you think the field of infant speech perception can develop...
 - What questions are unanswered?
 - What questions haven't been looked at?
 - Are we using the right methods/tasks/techniques to investigate these questions?
 - Are the theories complete?