LSci 51/Psych 56L: Acquisition of Language

Lecture 11

Phonological development IV

Announcements

Be working on the phonological development review questions

Be working on HW3 (due 10/28/19)

Prelinguistic speech perception

Infant hearing

Infant hearing is not quite as sensitive as adult hearing - but they *can* hear quite well and remember what they hear.

Example: Fetuses 38 weeks old

A loudspeaker was placed 10cm away from the mother's abdomen. The heart rate of the fetus went up in response to hearing a recording of the mother's voice, as compared to hearing a recording of a stranger's voice.

Infant hearing

Infant hearing is not quite as sensitive as adult hearing - but they *can* hear quite well and remember what they hear.

Example: Fetuses 8 months old

(Minai, Gustafson, Fiorentino, Jongman, & Sereno 2017)

A fetal biomagnetometer was used to measure fetal heart rate in English babies-to-be in response to a bilingual speaker speaking either English or Japanese. Fetal heart rates changed when they heard the unfamiliar, rhythmically distinct language (Japanese) after having heard a passage of English speech, while their heart rates did not change when they were presented with a second passage of English instead of a passage in Japanese.

https://www.sciencedaily.com/releases/2017/07/170718084600.htm

Infant hearing

Infant hearing is not quite as sensitive as adult hearing - but they *can* hear quite well and remember what they hear.

Example: Newborns

Pregnant women read a passage out loud every day for the last 6 weeks of their pregnancy. Their newborns showed a preference for that passage over other passages read by their mothers.

Infant hearing

Infant hearing is not quite as sensitive as adult hearing - but they *can* hear quite well and remember what they hear.

Example: Newborns (Moon, Lagercrantz, & Kuhl 2012)

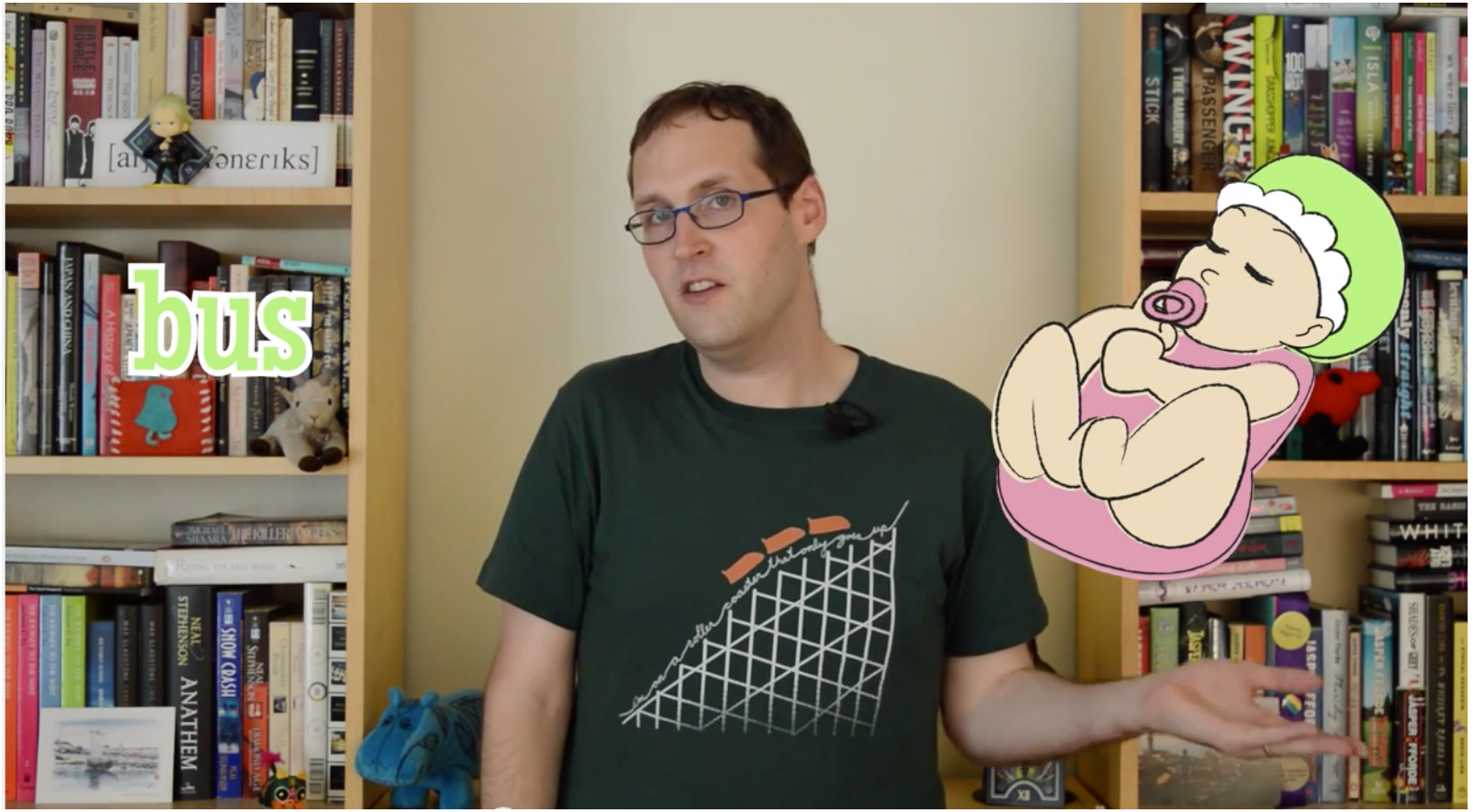
Swedish and English newborns heard different ambient languages while in the womb (Swedish and English, respectively), and were surprised when they heard non-native vowels only hours after birth.

Studying infant speech perception

http://www.thelingspace.com/episode-16

https://www.youtube.com/watch?v=3-A9TnuSVa8

beginning through 3:34: High Amplitude Sucking Procedure (HAS)



[Extra]

Studying infant speech perception

Researchers use indirect measurement techniques.

High Amplitude Sucking (HAS)

Infants are awake and in a quietly alert state. They are placed in a comfortable reclined chair and offered a sterilized pacifier that is connected to a pressure transducer and a computer via a piece of rubber tubing. Once the infant has begun sucking, the computer measures the infant's average sucking amplitude (strength of the sucks).

[Extra]

Studying infant speech perception

Researchers use indirect measurement techniques.

High Amplitude Sucking (HAS)

A sound is presented to the infant every time a strong or “high amplitude” suck occurs. Infants quickly learn that their sucking controls the sounds, and they will suck more strongly and more often to hear sounds they like the most. The sucking rate can also be measured to see if an infant notices when new sounds are played.

Studying infant speech perception

http://www.thelingspace.com/episode-16

https://www.youtube.com/watch?v=3-A9TnuSVa8

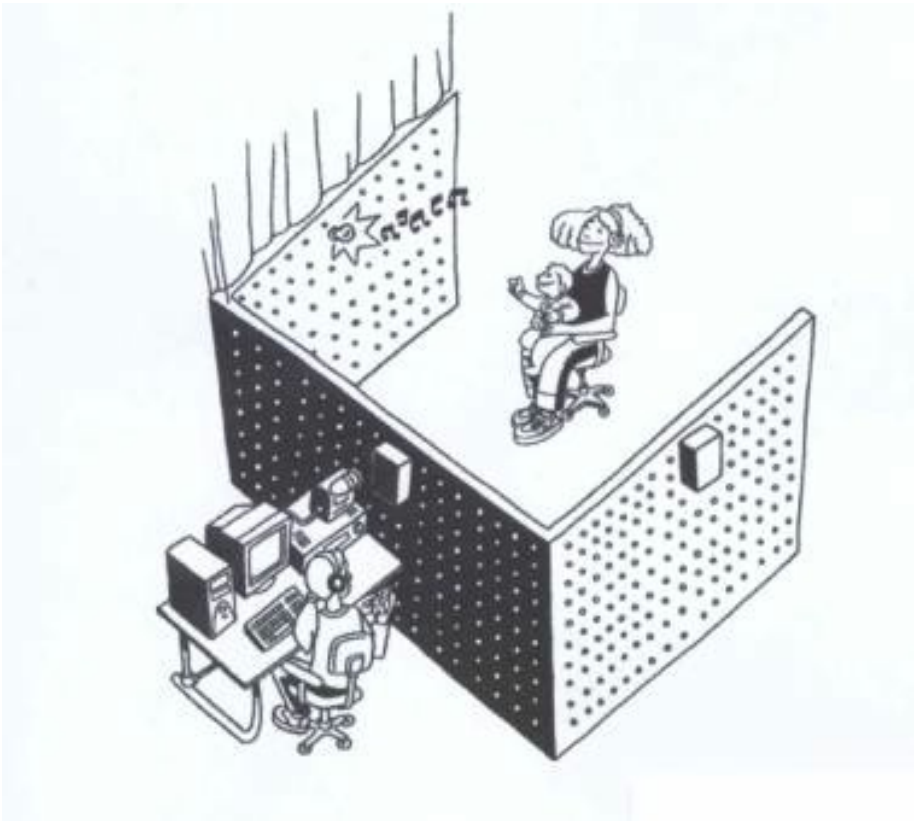
3:34 - 5:48: Head-Turn Preference Procedure

[Extra]

Studying infant speech perception

Researchers use indirect measurement techniques.

Head-Turn Preference Procedure



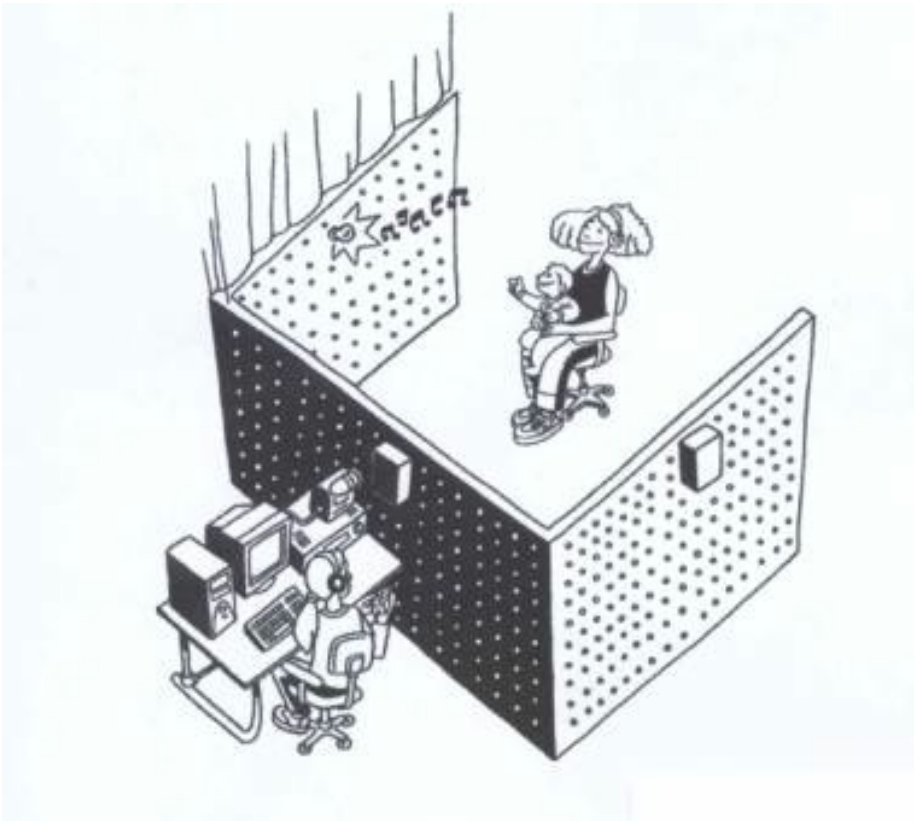
Infant sits on caretaker's lap. The wall in front of the infant has a green light mounted in the center of it. The walls on the sides of the infant have red lights mounted in the center of them, and there are speakers hidden behind the red lights.

[Extra]

Studying infant speech perception

Researchers use indirect measurement techniques.

Head-Turn Preference Procedure



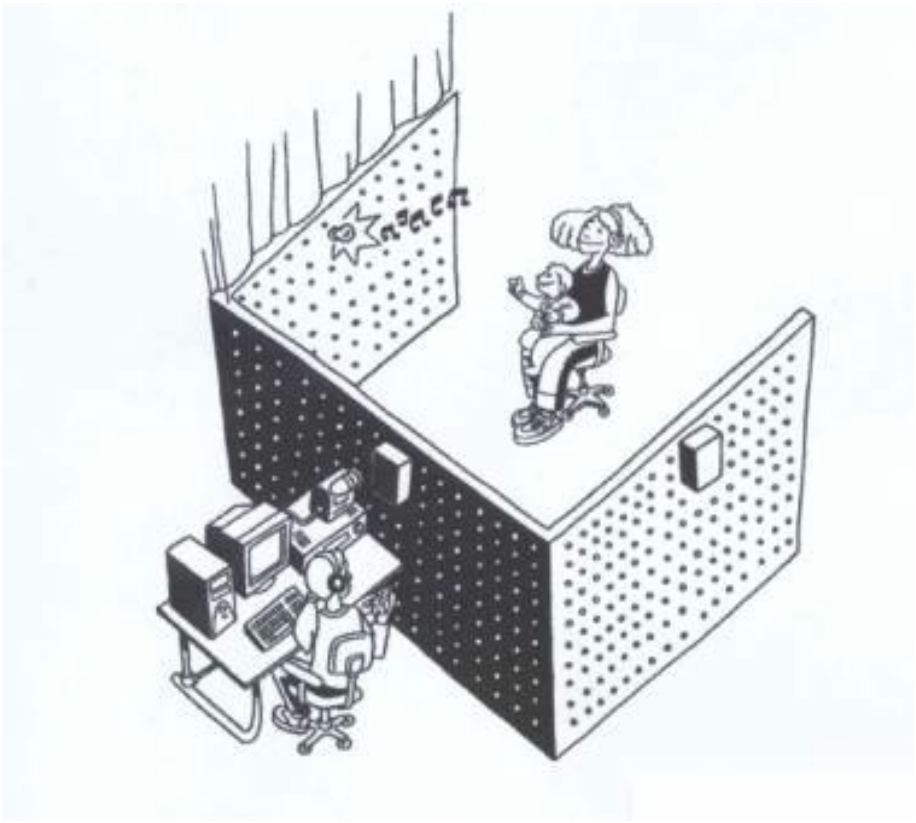
Sounds are played from the two speakers mounted at eye-level to the left and right of the infant. The sounds start when the infant looks towards the blinking side light, and end when the infant looks away for more than two seconds.

[Extra]

Studying infant speech perception

Researchers use indirect measurement techniques.

Head-Turn Preference Procedure



Thus, the infant essentially controls how long s/he hears the sounds. Differential preference for one type of sound over the other is used as evidence that infants can detect a difference between the types of sounds.

Studying infant speech perception

Researchers use indirect measurement techniques.

Head-Turn Technique

https://www.youtube.com/watch?v=WvM5bqUsbu8
Especially 0:31-1:15

[Extra]

Studying infant speech perception

Researchers use indirect measurement techniques.

Head-Turn Technique

Babies tend to be interested in moving toys. Using the presentation of a moving toy as a reward, babies are trained to turn their heads when they hear a change in the sound being presented.

[Extra]

Studying infant speech perception

Researchers use indirect measurement techniques.

Head-Turn Technique

A sound is played over and over, and then the sound is changed followed immediately by the presentation of the moving toy. After several trials, babies turn their heads when the sounds change even before the moving toy is activated.

Speech perception & speech production

Speech production capabilities also seem to impact early speech perception

Inhibiting [6-month-old] infants' tongue movements impedes their ability to distinguish between speech sounds, researchers have found. The study is the first to discover **a direct link between infants' oral-motor movements and auditory speech perception**.

https://www.sciencedaily.com/releases/2015/10/151012180801.htm, reporting findings of Bruderer, Danielson, Kandhadai, & Janet F. Werker 2015.

"The freedom to make small gestures with their tongue and other articulators when they listen to speech may be an important factor in babies' perception of the sounds." - Janet Werker

Categorical perception

One feature of infants' speech perception: categorical perception.

Categorical perception occurs when a range of stimuli that differ continuously are perceived as belonging to only a few categories with no degrees of difference within those categories.

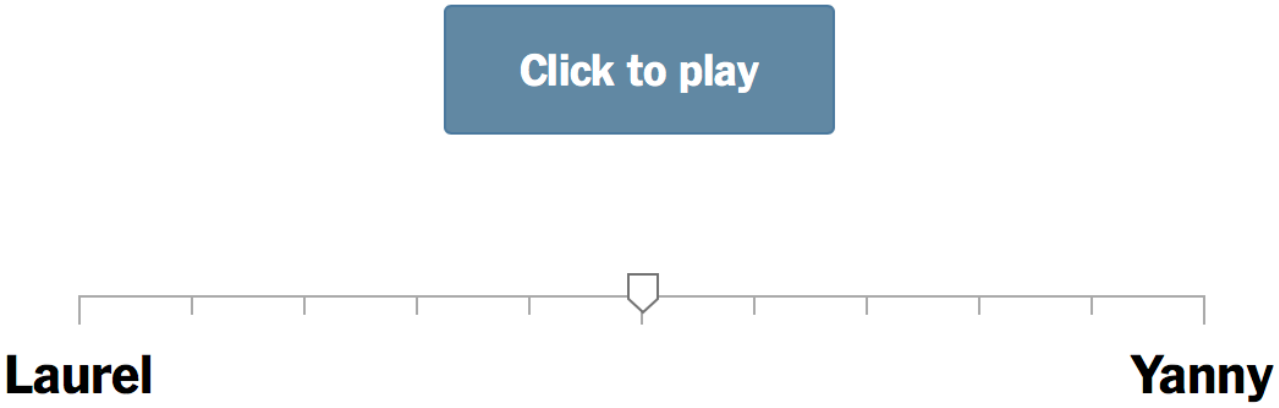
Actual stimuli

Perception of stimuli

Categorical perception

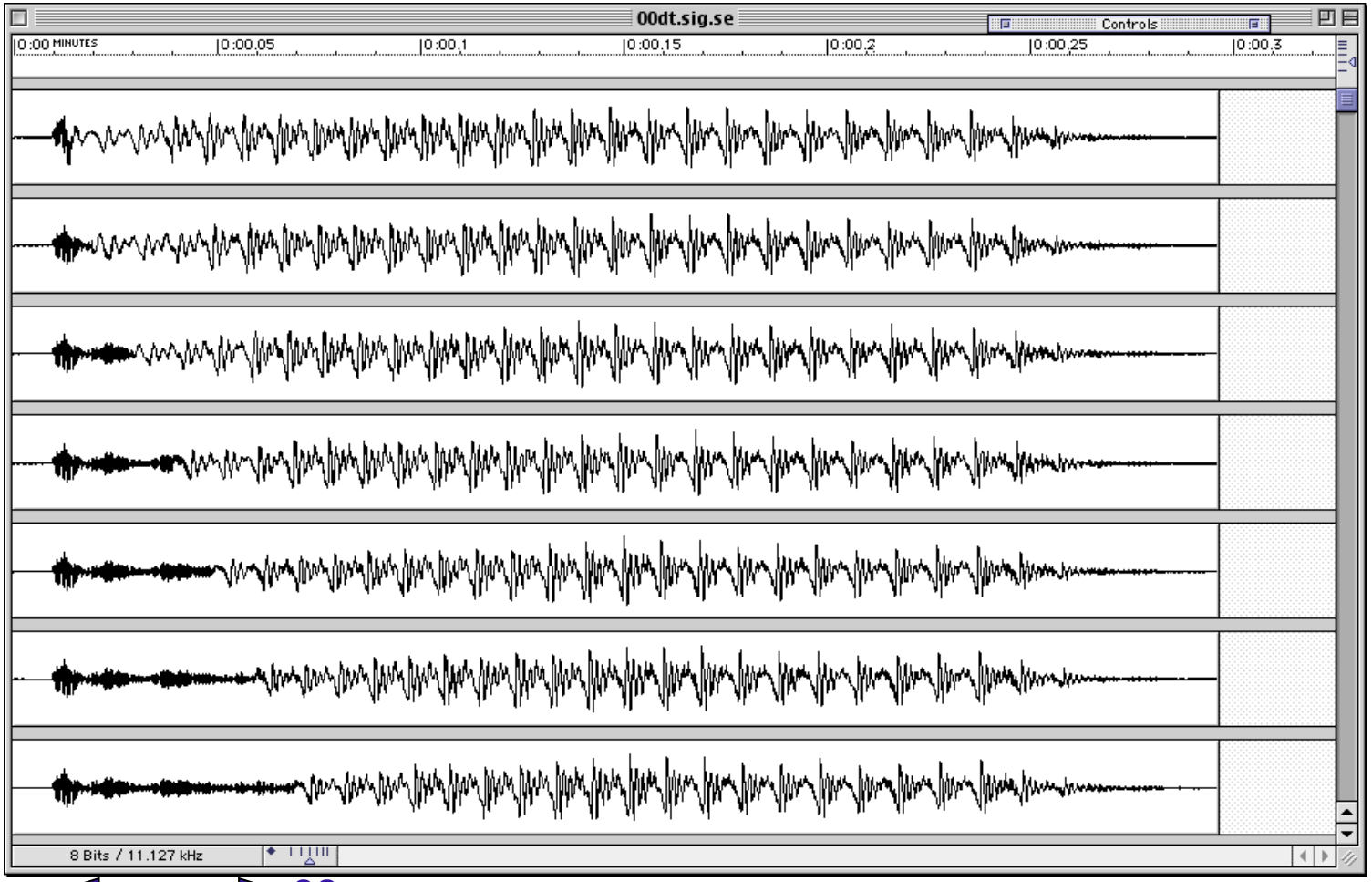
Of whole words: Laurel vs. Yanny

https://www.nytimes.com/interactive/2018/05/16/upshot/audio-clip-yanny-laurel-debate.html#k=-0.228



Categorical perception

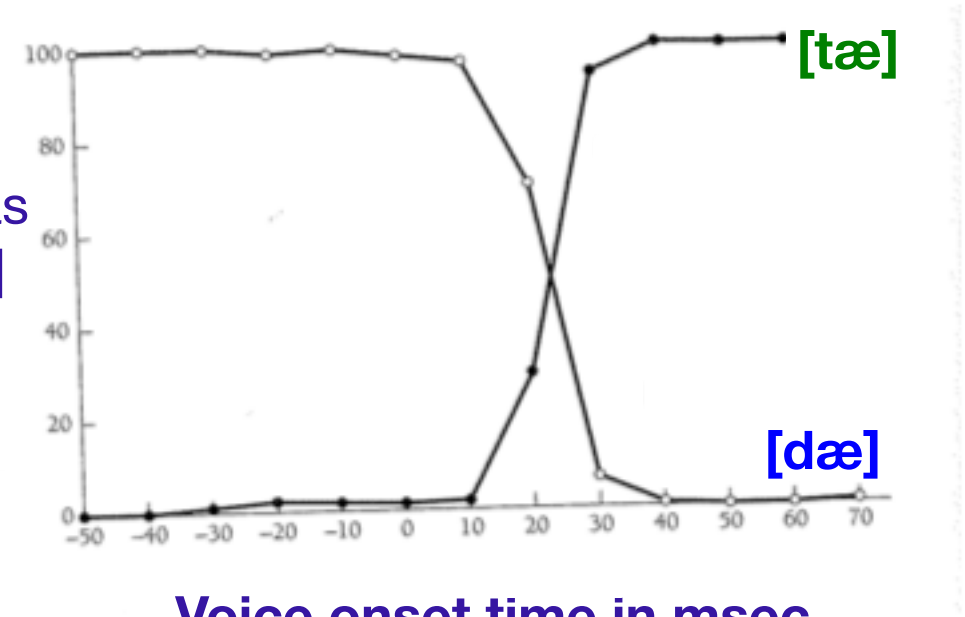
Adult categorical perception: Voice Onset Time (VOT)



Categorical perception

Adult categorical perception: Voice Onset Time (VOT)

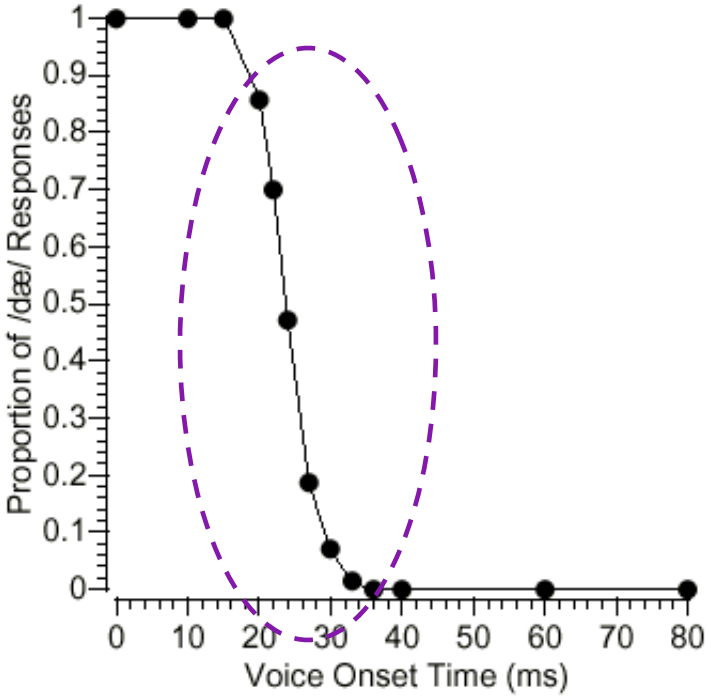
% of responses as either [tæ] or [dæ]



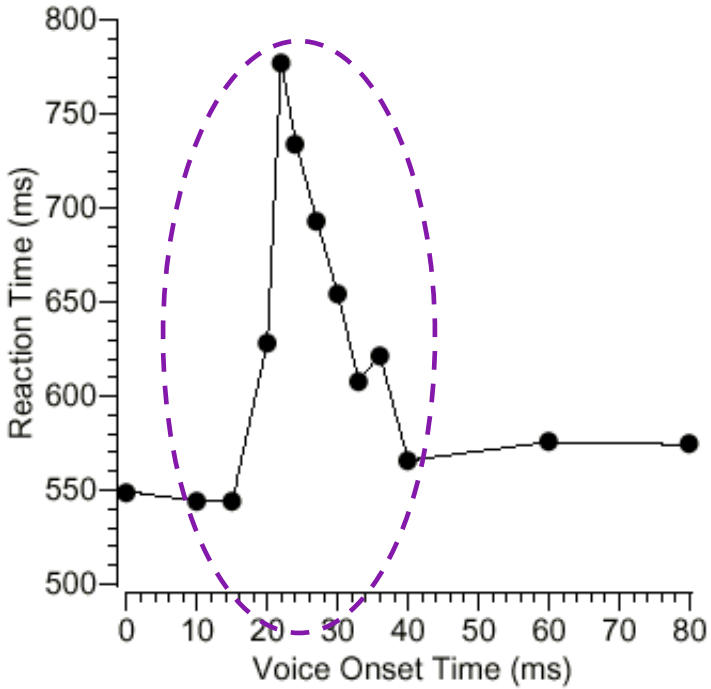
Categorical perception

Adult categorical perception: Voice Onset Time (VOT)

Uncertainty at category boundary



Decision between dæ/tæ



Time to make decision

Categorical perception

Adult categorical perception: Voice Onset Time (VOT)

Within-category discrimination is hard,
across-category discrimination is easy

D	0ms	20ms	D
D	20ms	40ms	T
T	40ms	60ms	T

Categorical perception

http://www.thelingspace.com/episode-4

https://www.youtube.com/watch?v=dtf8zGQj9GY

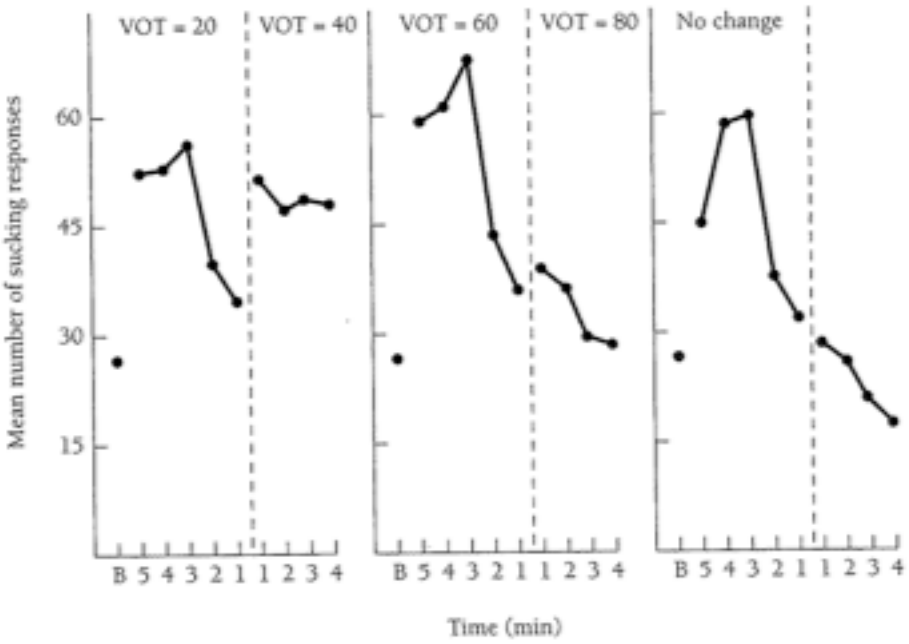
5:39-6:59

Categorical perception

Infant categorical perception: Voice Onset Time (VOT)

Eimas et al. 1971: HAS technique

across category | within category | control (baseline)



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Infant categorical perception: Voice Onset Time (VOT)

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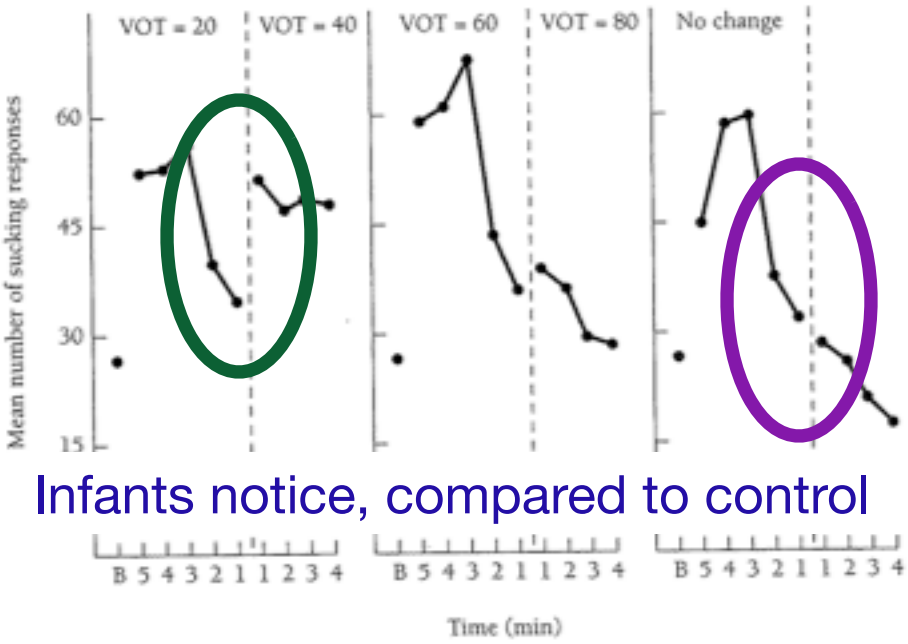


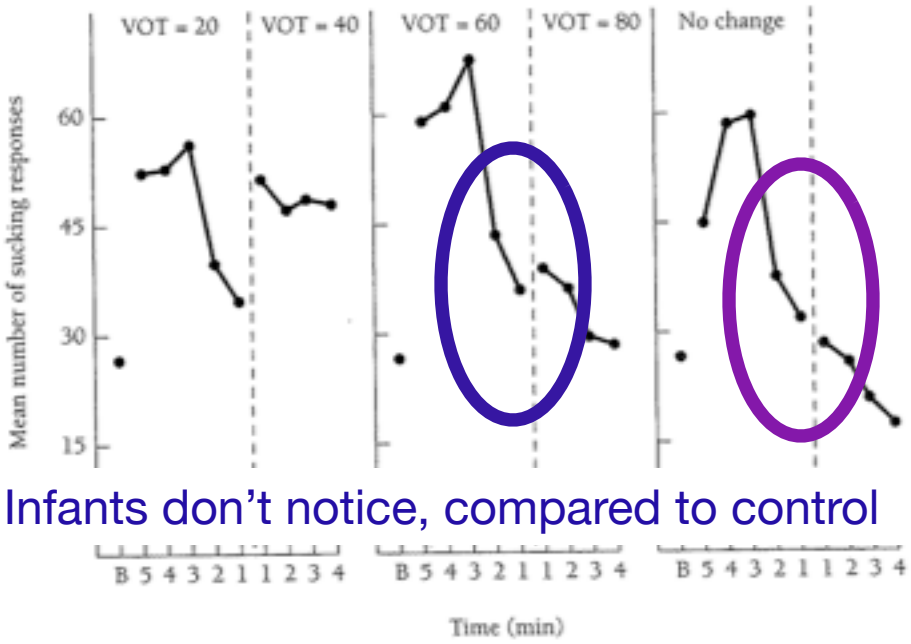
Infants notice, compared to control

Categorical perception

Infant categorical perception: Voice Onset Time (VOT)

Eimas et al. 1971: HAS technique

across category | within category | control (baseline)



Infants don't notice, compared to control

Categorical perception

Infant categorical perception: Impact on later language development

From Curtin & Zamuner 2014 (Box 1):

> Infant ability to discriminate two acoustically distinct vowels (/u/ and /y/) at six months is correlated with language abilities at 13–24 months of age (Tsao et al. 2004).

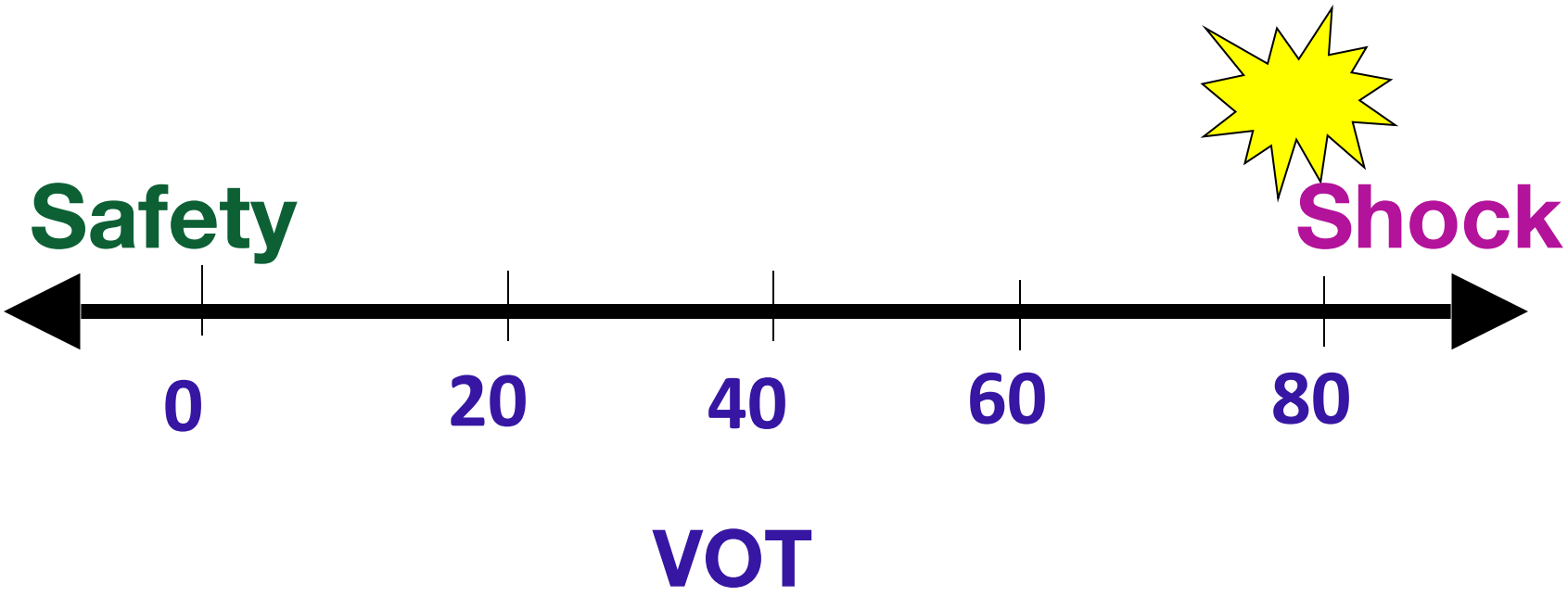
Categorical perception

Categorical perception: a special human ability?

Categorical perception is not specific to the human ear, though - it's a feature shared with other mammals like chinchillas (tested with an **Avoidance Conditioning Procedure**)!

Avoidance conditioning procedure

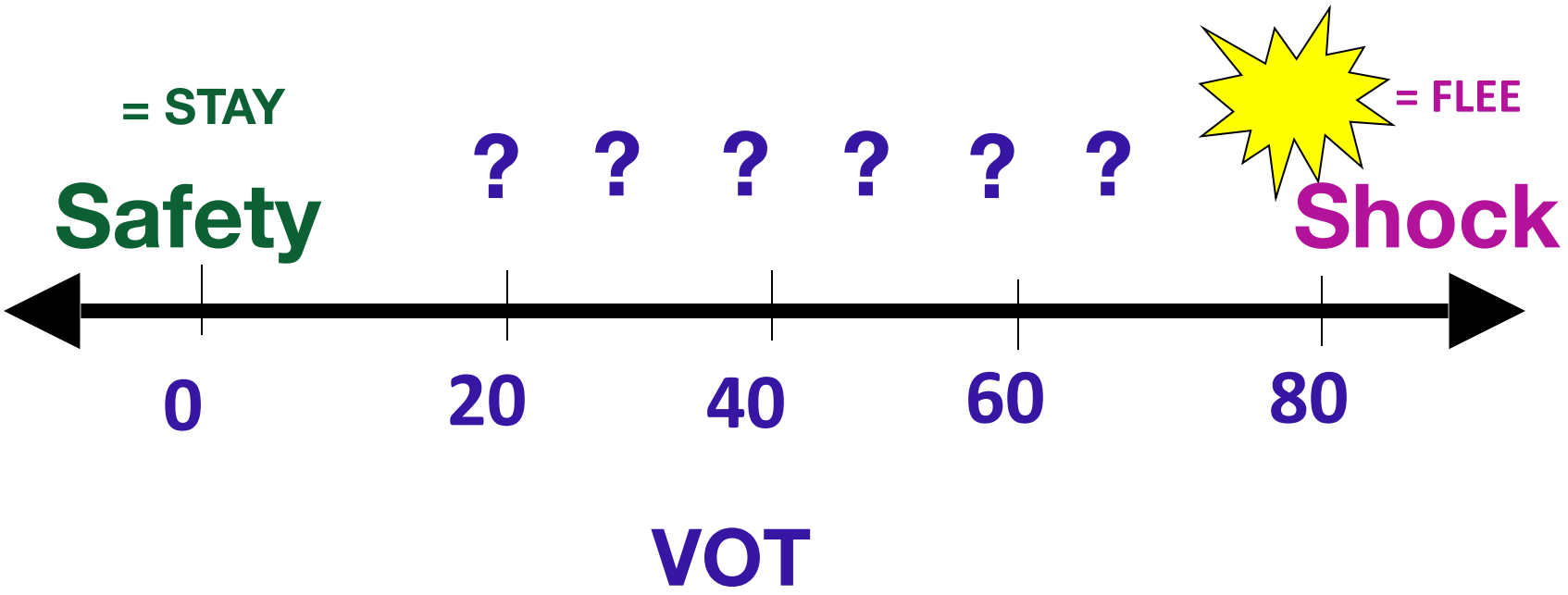
- Speech sound at one end of the continuum paired with shock
- Other end paired with safety



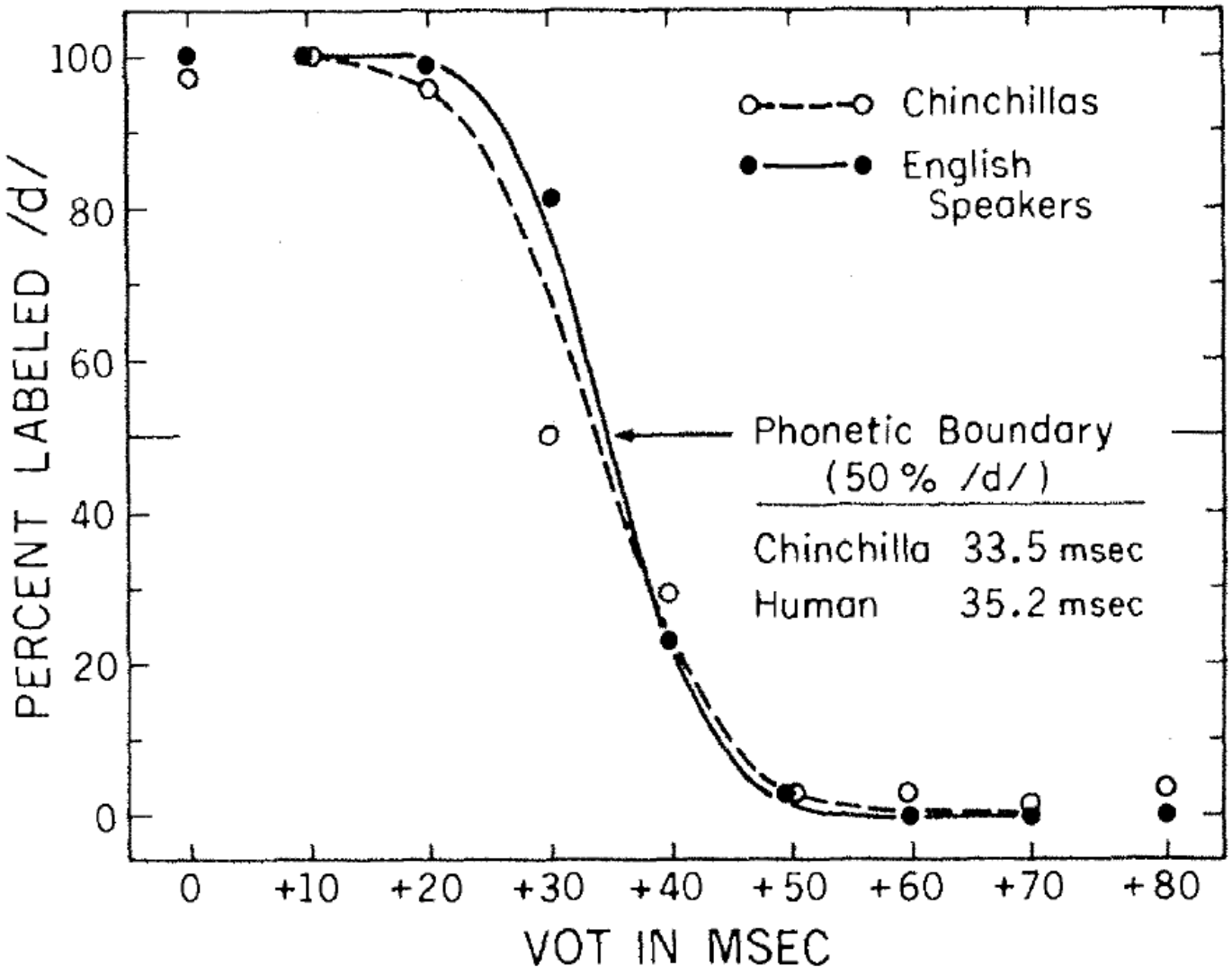
Avoidance conditioning procedure

Animals learn to “avoid” shock.

What will they do for between cases?



Kuhl & Miller (1978)



Why categorical perception is so helpful: The lack of invariance problem

"…no two utterances of a particular phoneme—for example, the /p/ in *pick*—are identical….might sometimes produce her /p/ sound with a VOT of 70 ms, sometimes with a VOT of 90 ms….might produce /p/ with relatively shorter VOTs….[or] pronounce the sound with longer VOTs. Add to that the fact that the sounds abutting the /p/ will bleed into the consonant; the /p/ sound in *pick*, for example, is acoustically different from the /p/ sound in *poke*. **An infinite number of acoustic patterns can map into a single speech sound.**"

- Myers 2017, on **the lack of invariance problem**

Why categorical perception is so helpful: The lack of invariance problem

"…To convince yourself of how difficult it can be to translate acoustic cues into words, try any commercially available speech-recognition interface such as Apple's Siri or Amazon's Alexa. Say a single, monosyllabic word such as *pack* clearly and slowly, and the system is reasonably likely to identify it correctly. However, if you repeat the word *pack* quickly, you may get a multitude of responses; in different tries, Siri thought I was saying *back*, *beck*, *talk*, and *part*."

- Myers 2017, on **the lack of invariance problem**

Why categorical perception is so helpful: The lack of invariance problem

"….the human speech system does not deliver the entire auditory content to the point of conscious awareness. Rather, **we usually can perceive only acoustic differences that matter for meaning**…may be in place to help our brain's limited resources focus on only the most important aspects of the speech signal."

- Myers 2017, on the utility of categorical perception

Infant-directed speech

The nature of infant-directed speech

Motherese/infant-directed speech/child-directed speech

Intonational contour is greatly exaggerated:

- higher-pitched voice, wider range of pitches, longer pauses, shorter phrases, slower tempo (vowels are prolonged)

Motherese could be helpful for language learning:
likely to highlight important features of speech, and provide more prototypical examples of a language's speech sounds

How motherese helps

Greater discriminability of phonemes (contrasting sounds in a language) in child-directed speech may help children establish phonemic categories (that signal meaning contrasts)

[b] and [p] are distinct phonemic categories in English.

We know because "big" is a different word from "pig".

Support: Mothers who produce more discriminable vowels in their infant-directed speech have infants who demonstrate better speech perception skills in laboratory tests.

How motherese helps

Greater discriminability of phonemes (contrasting sounds in a language) in child-directed speech may help children establish phonemic categories (that signal meaning contrasts)

[b] and [p] are distinct phonemic categories in English.

We know because "big" is a different word from "pig".

Support: A quantitative and modeling analysis of English child-directed speech indicates vowel tokens are helpfully exaggerated, and so provide high quality input for learning (Adriaans & Swingley 2017).

Support: A quantitative analysis of Nepali child-directed speech indicates vowel tokens are especially salient in syllables (compared with consonants), and so provide high quality input for learning those vowels (Benders, Pokharel, & Demuth 2019).

How motherese helps…adults?

Golinkoff & Alioto 1995: adults learned words in a foreign language better if the words were presented in infant-directed rather than adult-directed speech

But not motherese for everyone…

While motherese may be very useful, it can't be *required* for language acquisition (even if it's really helpful) since not all cultures use it. Some cultures (ex: Samoans, Papua New Guineans, Mayans, US African Americans in the rural south) don't address speech to prelinguistic children at all - so those children must learn some other way.

Links between social cues and sound learning

Conboy, Brooks, Meltzoff, & Kuhl 2015: 10-month-olds who engaged in more gaze shifting (when a baby makes eye contact and then looks at the same object that the other person is looking at) during sessions with a foreign language tutor showed a boost in a brain response that indicates language learning.

https://www.sciencedaily.com/releases/2015/07/150727100024.htm

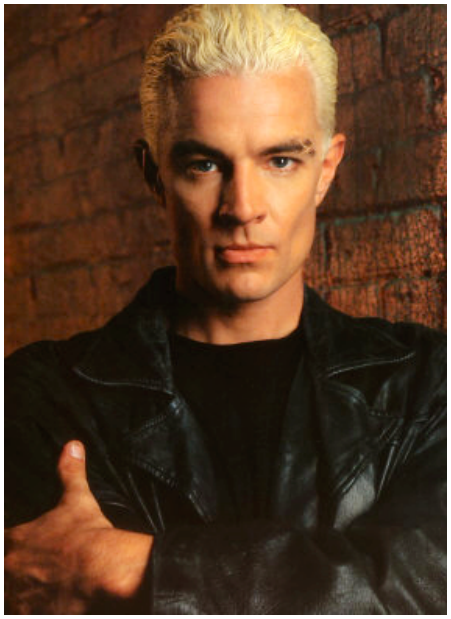
What this means: Sound learning may be greatly facilitated by these kind of social cues in a communicative context.

Recap: Speech sound development

There are several experimental techniques that can be used to examine infant speech perception. One useful ability infants seem to have is categorical perception. It can help with the lack of invariance problem for speech sounds.

Infant-directed speech (motherese) tends to have several properties that make it helpful for learning the sounds of the language.

Questions?



You should be able to do all of HW3, and all the phonological development review questions.