Psych 215L: Language Acquisition

Lecture 3

Experimental & Computational Methods

Experimental Methods: What, When, and Where

Experimental Methods

How do we tell what infants know, or use, or are sensitive to?

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).

Experimental Methods

How do we tell what infants know, or use, or are sensitive to?

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.

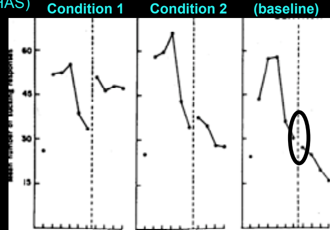
Experimental Methods

How do we tell what infants know, or use, or are sensitive to?

Researchers use indirect measurement techniques.

High Amplitude Sucking (HAS)

Test Condition 1 **Test Condition 2** **Control (baseline)**



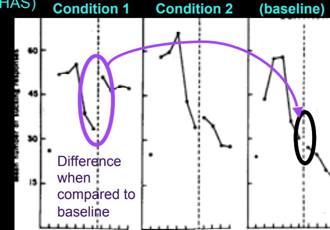
Experimental Methods

How do we tell what infants know, or use, or are sensitive to?

Researchers use indirect measurement techniques.

High Amplitude Sucking (HAS)

Test Condition 1 **Test Condition 2** **Control (baseline)**

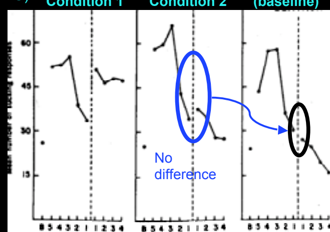


Experimental Methods

How do we tell what infants know, or use, or are sensitive to?

Researchers use indirect measurement techniques.

High Amplitude Sucking (HAS)



Experimental Methods

How do we tell what infants know, or use, or are sensitive to?

Researchers use indirect measurement techniques.

High Amplitude Sucking (HAS)

Infants have sophisticated discrimination abilities, but they don't abstract sounds into categories the way that adults do.

Adult perception

"dæ" — phonemic category

"tæ" — phonemic category

Experimental Methods

How do we tell what infants know, or use, or are sensitive to?

Researchers use indirect measurement techniques.

High Amplitude Sucking (HAS)

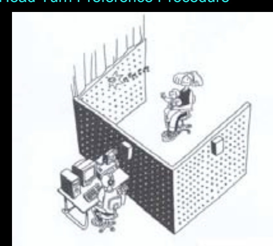
Infants have sophisticated discrimination abilities, but they don't abstract sounds into categories the way that adults do.

Infant perception

"dæ 1" "dæ 2" "tæ 1" "tæ 2"

Another useful indirect measurement

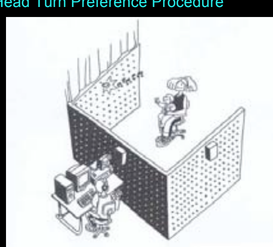
Head Turn Preference Procedure

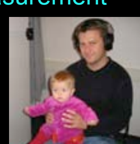


Infant sits on caretaker's lap. The wall in front of the infant has a green light mounted in the center of it. The walls on the sides of the infant have red lights mounted in the center of them, and there are speakers hidden behind the red lights.

Another useful indirect measurement

Head Turn Preference Procedure

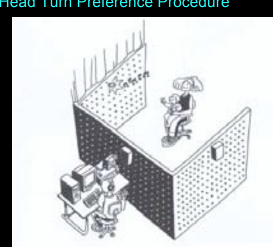


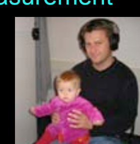


Sounds are played from the two speakers mounted at eye-level to the left and right of the infant. The sounds start when the infant looks towards the blinking side light, and end when the infant looks away for more than two seconds.

Another useful indirect measurement

Head Turn Preference Procedure

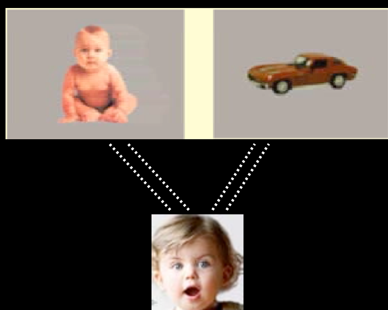




Thus, the infant essentially controls how long he or she hears the sounds. Differential preference for one type of sound over the other is used as evidence that infants can detect a difference between the types of sounds.

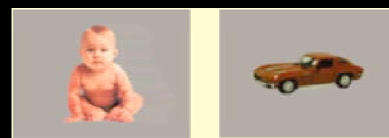
Eyetracking: measures fixations on target picture

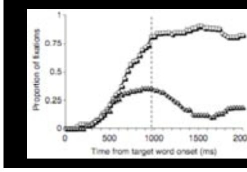
"Where's the baby?"



Eyetracking: measures fixations on target picture

"Where's the baby?"



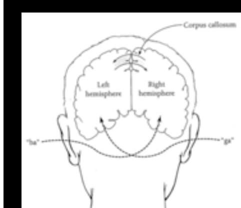


"Where's the **baby**?"

"Where's the **vaby**?"

Dichotic Listening Tasks

Use the fact that contralateral connections from the ears to the brain are stronger than ipsalateral connections. Experimenters present two tasks at the same time, one to each ear, and ask subjects which one is perceived.



If they say the left ear's stimulus, then the right side of the brain processes that info. If they say the right ear's stimulus, then the left side of the brain processes that info.

Looking at children's brains

ERPs: Event-related brain potentials, gauged via electrode caps. The location of ERPs associated with different mental activities is taken as a clue to the area of the brain responsible for those activities.

Good: non-invasive, relatively undemanding on the subject, provide precise timing on brain events

Bad: poor information on exact location of ERP since just monitoring the scalp

Looking at children's brains

Brain-imaging techniques: gauge what part of the brain is active as subjects perform certain tasks

PET scans: Positron emission topography scans
- subjects inhale low-level radioactive gas or injected with glucose tagged with radioactive substance
- experimenters can see which parts of the brain are using more glucose (requiring the most energy)

fMRI scans: functional magnetic resonance imaging
- subjects have to be very still inside MRI machine, which is expensive to operate
- experimenters can see which parts of the brain are getting more blood flow or consuming more oxygen

Looking at children's brains

Brain-imaging techniques: gauge what part of the brain is active as subjects perform certain tasks

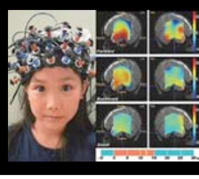
MEG: Magnetoencephalography
- subjects have to be very still
- experimenters can see which parts of the brain are active

Looking at children's brains

Brain-imaging techniques: gauge what part of the brain is active as subjects perform certain tasks

Optical Topography: Near-infrared spectroscopy (NIRS)

- newest technique
- transmission of light through the tissues of the brain is affected by hemoglobin concentration changes, which can be detected



Computational Methods: How

Computational Methods

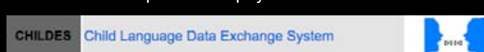
Control over the entire learning mechanism:

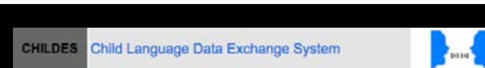
- what hypotheses the (digital) child considers
- what data the child learns from
- how the child updates beliefs in different hypotheses

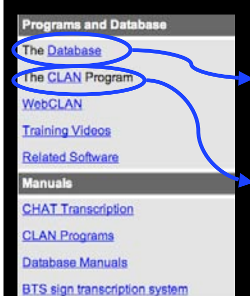
Ground with empirical data available

- want to make this as realistic as possible (ex: use actual data distributions, cognitively plausible update procedures)
- a good source of empirical data: CHILDES database

http://childes.psy.cmu.edu/







Download annotated transcripts from the database.

Download the program to search these transcripts, and its manual.

Quickie CLAN demonstration

Back to modeling

Gauges of modeling success & contributions to science

Formal sufficiency: does the model learn what it's supposed to learn when it's supposed to learn it from the data it's supposed to learn it from?

Developmental compatibility: Does it learn in a psychologically plausible way? Is this something children could feasibly do?

Explanatory power: what's the crucial part of the model that makes it work? How does this impact the larger language acquisition story?

Sample learning models

Phoneme acquisition (Vallabha et al . 2007): learning contrastive sounds from raw acoustic data

Word segmentation (Gambell & Yang 2006): learning to identify words in fluent speech from streams of syllables

Categorization (Mintz 2003): learning to identify what category a word is (noun, verb) from segmented speech

Sample learning models

Morphology (Rumelhart & McClelland 1986, Yang 2002, Albright & Hayes 2002, Yang 2005): learning to identify past tense affixes from speech segmented into phonemes/syllables/words

Learning the interpretation of referential elements (Foraker et al. 2007, 2009, Pearl & Lidz (2009): learning to identify syntactic category and semantic referent of *one* from segmented speech and referents in the world

Syntactic acquisition (Reali & Christiansen 2005, Kam et al. 2008, Pearl & Weinberg 2007): learning to identify correct word order (rules) from speech segmented into words

Stress (Pearl 2008): learning to identify correct stress patterns (and rules behind them) from words with stress contours

General Modeling Process

(1) Decide what kind of learner the model represents (ex: normally developing 6-month-old child learning first language)

(2) Decide what data the child learns from (ex: Bernstein corpus from CHILDES) and how the child processes that data (ex: data divided into syllables)

(3) Decide what hypotheses the child has (ex: what the words are) and what information is being tracked in the input (ex: transitional probability between syllables)

(4) Decide how belief in different hypotheses is updated (ex: based on transitional probability minima between syllables)

General Modeling Process

(5) Decide what the measure of success is

- precision and recall (ex: finding the right words in a word segmentation task)

- matching an observed performance trajectory (ex: English past tense acquisition often has a U-shaped curve)

- achieving a certain knowledge state by the end of the learning period (ex: knowing there are 4 vowel categories at the end of a phoneme identification task)

- making correct generalizations (ex: preferring a correctly formed sentence over an incorrectly formed one)

The Aim

Dovetailing between experimental and computational methods, each feeding into the other to increase general understanding of language acquisition.