

LANGUAGE

Professor John Gabrieli

LANGUAGE

- **Comprehension**
 - Auditory**
 - Visual**
- **Production**
 - Speaking**
 - Writing**

**Endlessly generative - 100 trillion years to
memorize all the sentences we can
produce**

LANGUAGE

- Phonology - sounds of language
- Syntax (grammar, structure)
- Semantics (meaning)
- Pragmatics

Discourse

Emotional Comprehension/Production

PHONOLOGY

- Phonemes are building blocks of speech sounds (*boy* vs. *toy*)
- Humans use 100 phonemes - 45 in English (26 letters; letters are not phonemes - “hot” and “cold”)
- born to hear all phonemes - use or lose it in development after 6/8 months
- we can understand 250 words/min - normal rate is about 180 words/min = 14 phonemes/second in continuous stream

HEARING A WORD

acoustic information to the ear

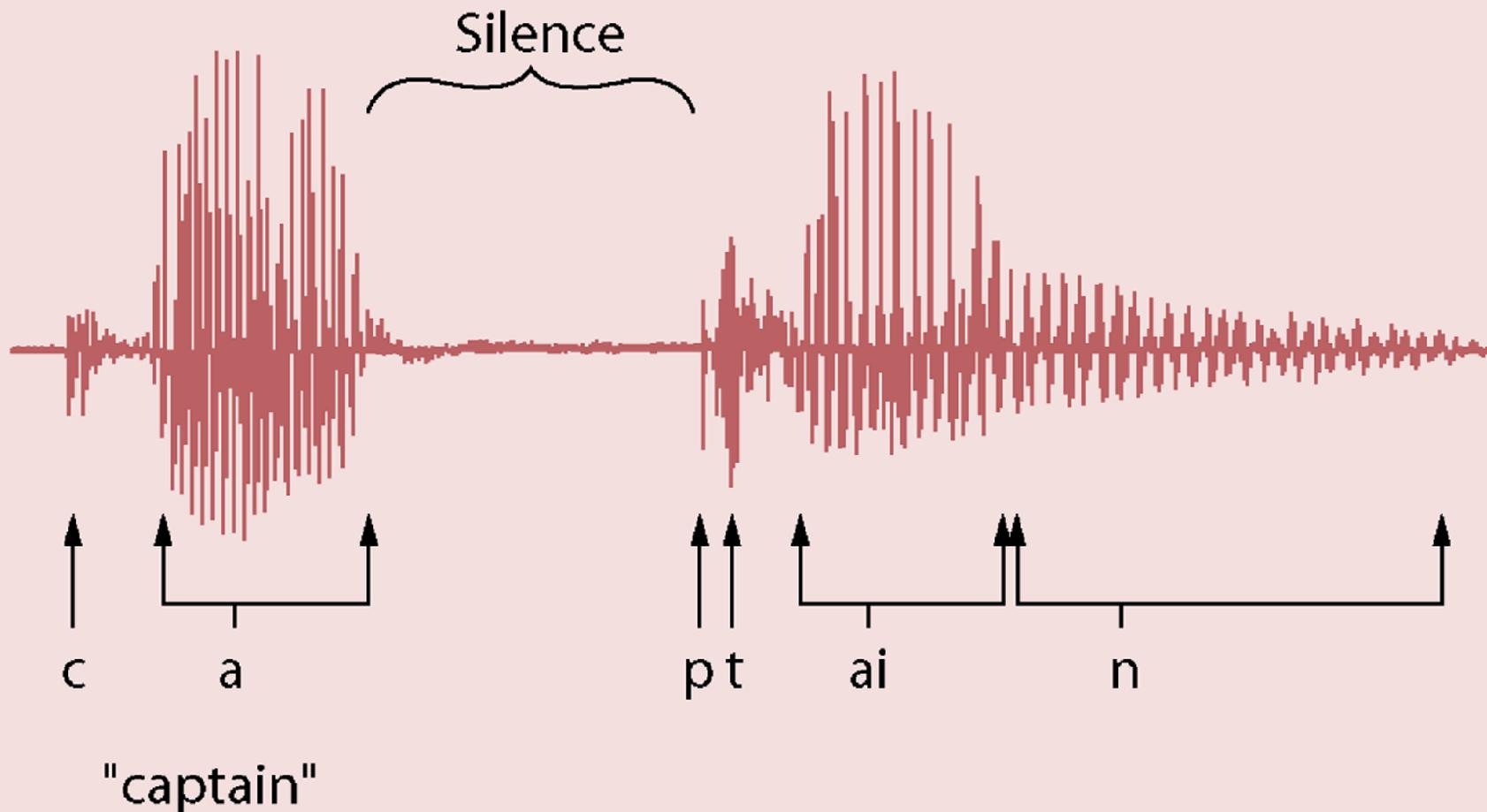


phonemes



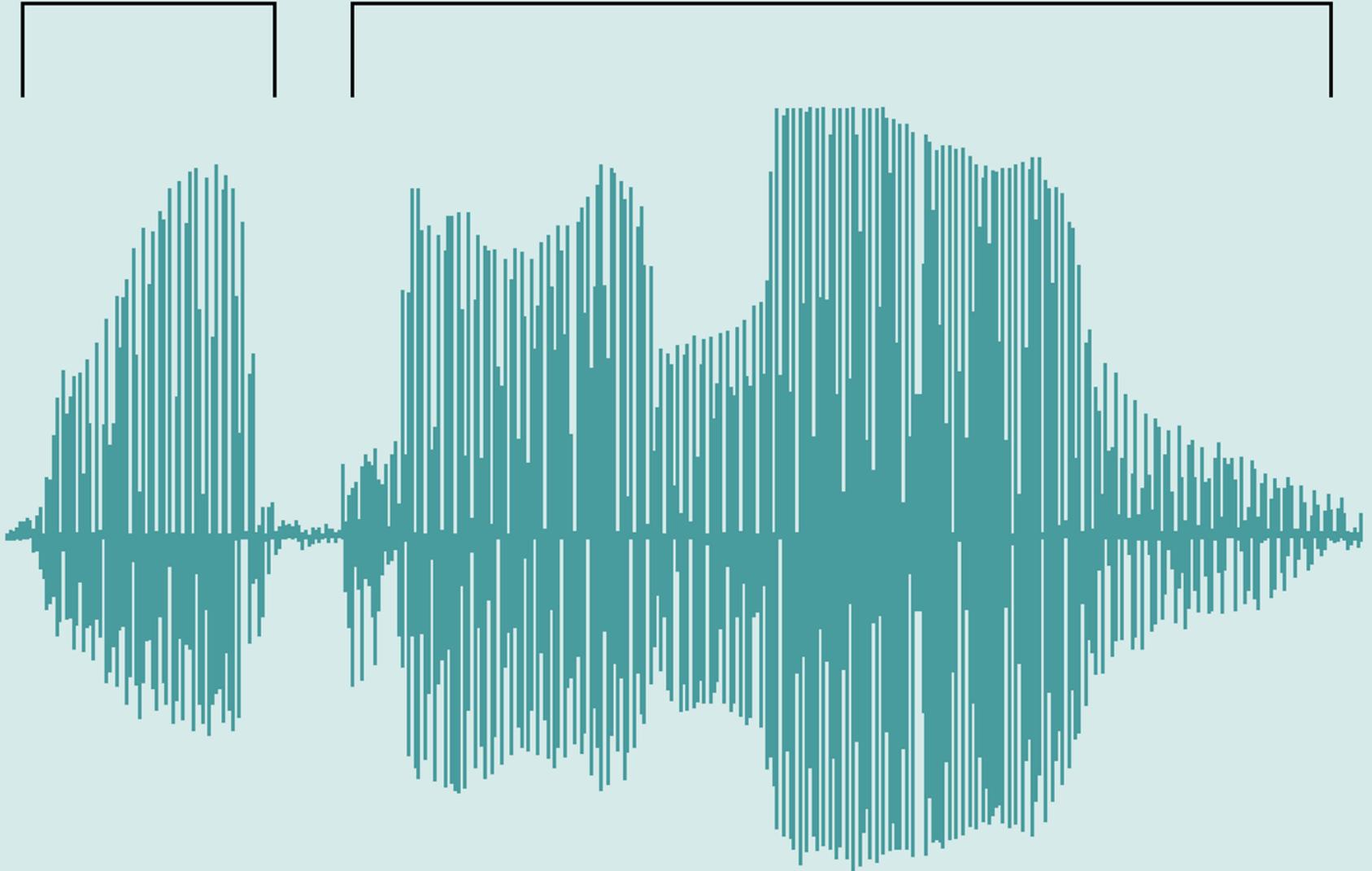
word?

Difference Between a Word and What you Hear

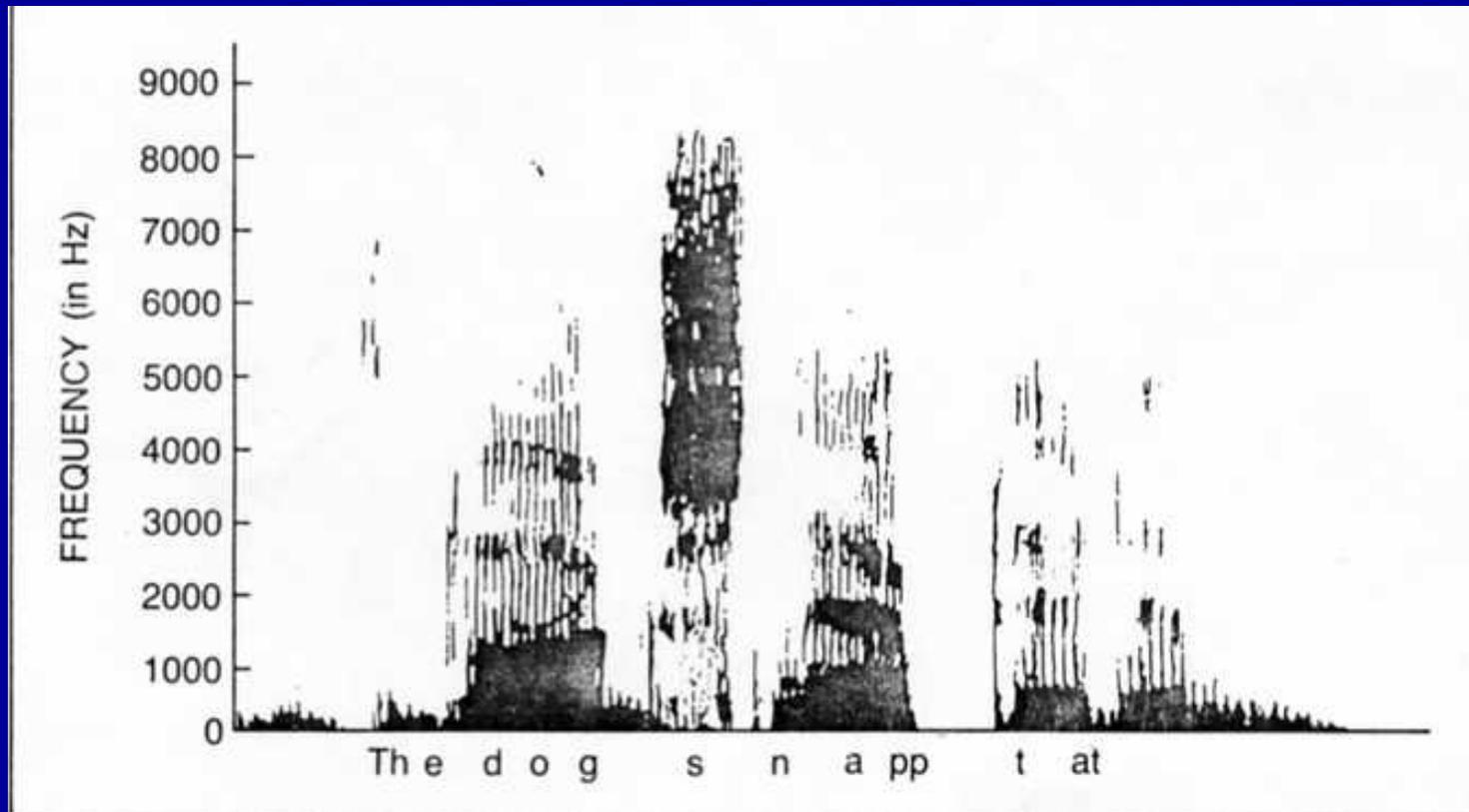


What

do you mean?



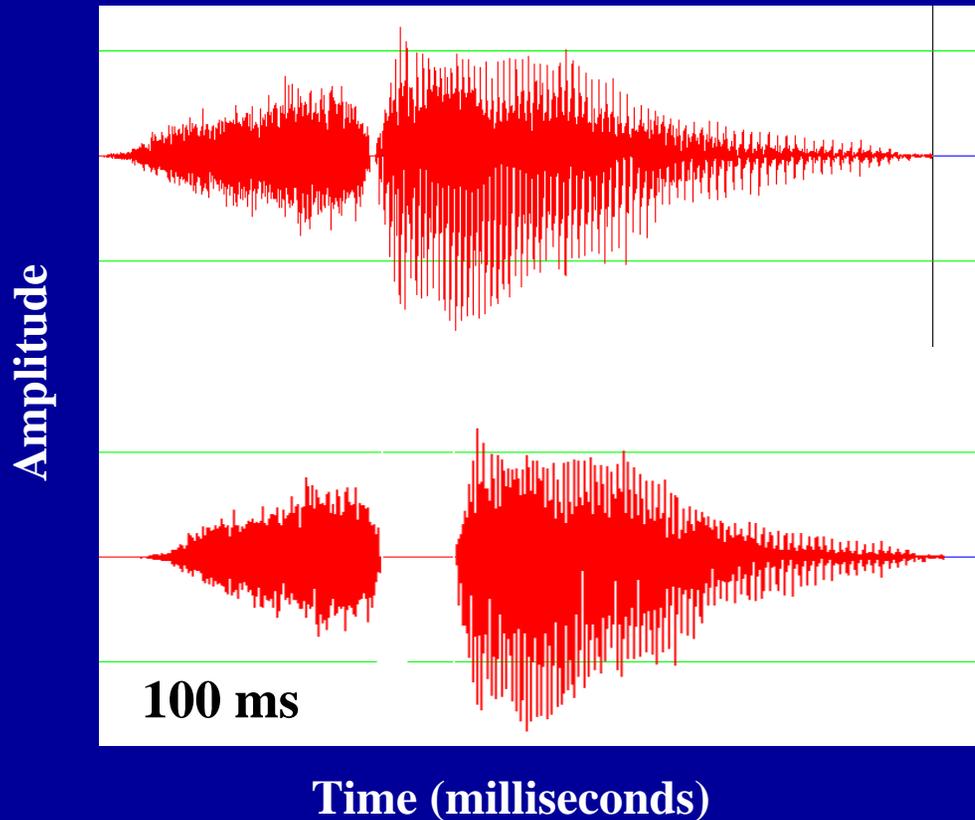
The dog snapped at



Spectrogram from sentence “John said that the dog snapped at him.”

Note that the gaps between sounds generally occur within the words, rather than between words.

For speech, 10's of milliseconds can change the meaning of a word



“say”



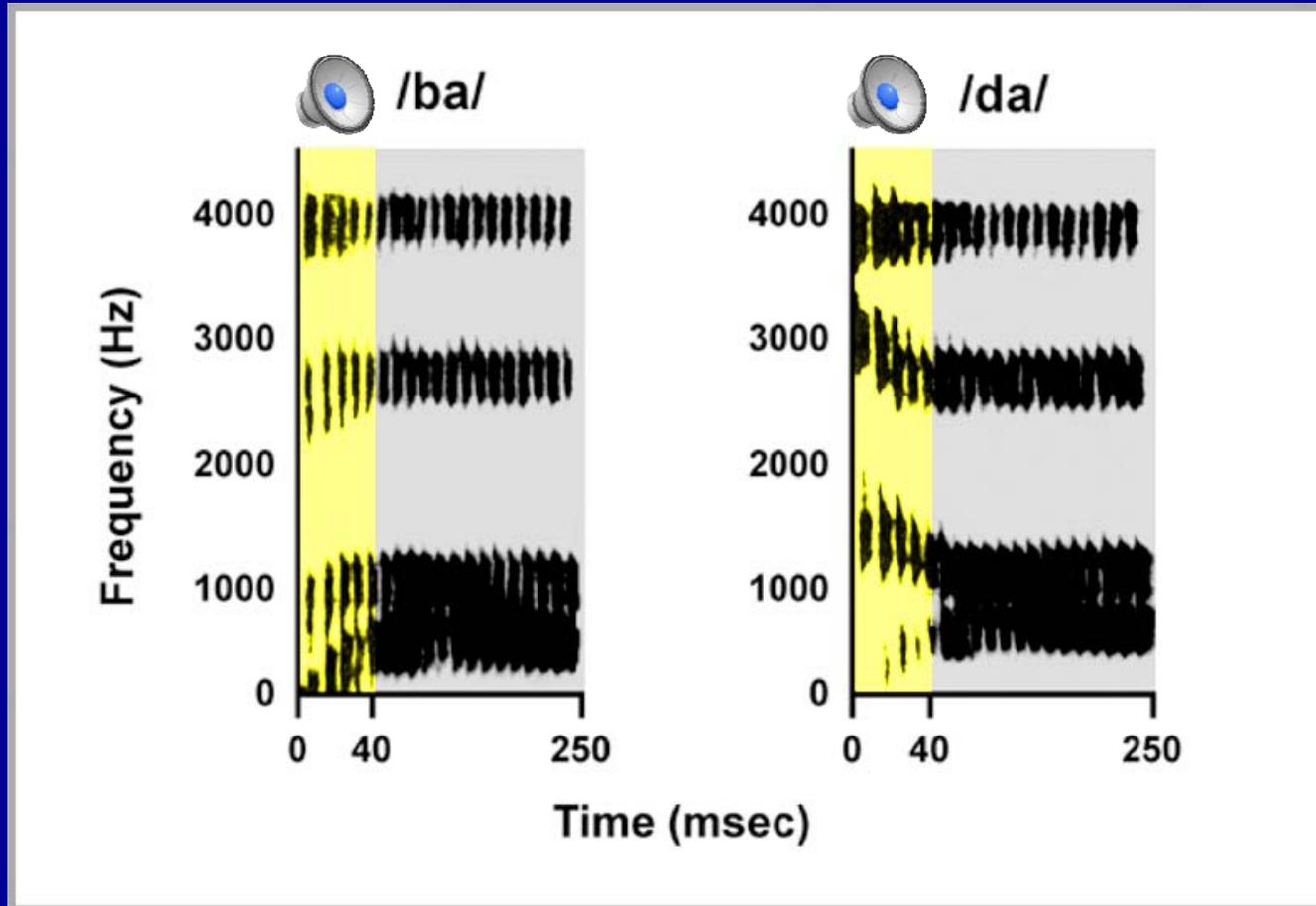
“stay”



© Paula Tallal. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/fairuse>.

These waveforms are identical except for an inserted 100ms silent gap, yet we hear two different words.

10's of milliseconds can determine which syllable we hear



Many speech sounds (phonemes) differ only by brief spectral and/or temporal changes, specifically within 10's of milliseconds

WHAT DO YOU HEAR?



WHAT DO YOU HEAR?



“little” from Mary saw the three little pigs in the corridor



“little” in isolation



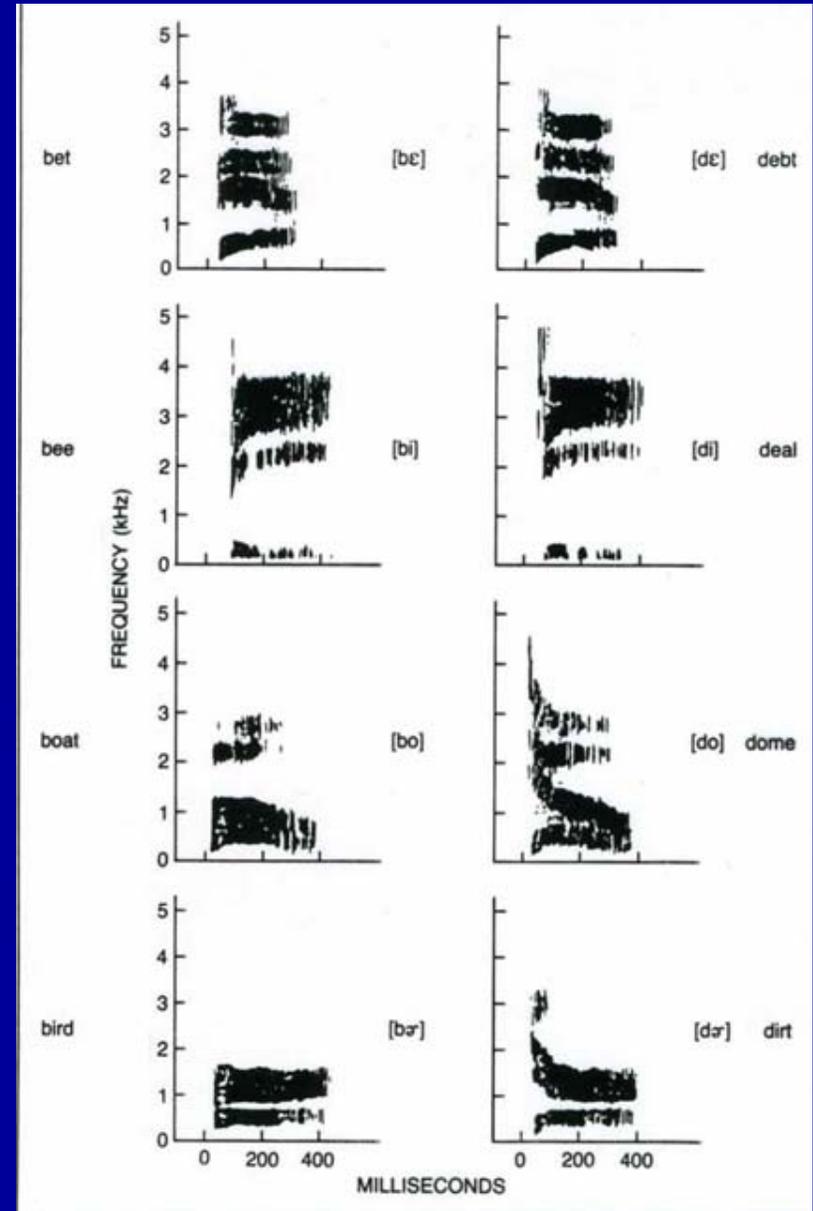
Mary saw the three little pigs in the corridor

Changes in the lead consonant are induced by the following vowel

problem of invariance

Spectrographs for /b/ and /d/ syllable families:

- The /b/ sounds in *bet* and *bird* are perceived similarly, yet spectrographs are quite different.
- The /b/ and /d/ sounds in *bet* and *debt* have similar spectrographs, but are perceived as different phonemes.



Source: Jusczyk, P. W., L. B. Smith, and C. Murphy. "The Perceptual Classification of Speech." *Attention, Perception, & Psychophysics* 30, no. 1 (1981): 10-23. © Springer. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/fairuse>.

CATEGORICAL PERCEPTION

Many different sounds must be categorized into phonemes & words

CATEGORICAL PERCEPTION

Categorical Perception

speech sounds vary *continuously*

-20 -10 0 10 20 30 40 50 60 70 80

... but we perceive them in *categories*

-20 -10 0 10 20 30 40 50 60 70 80

“BA”



”PA”



VOICE ONSET TIME (VOT)

- VOT = length of time from when a consonant is released to when voicing begins (vibration of vocal cords)
- negative VOT = vocal cords vibrate before stop is released

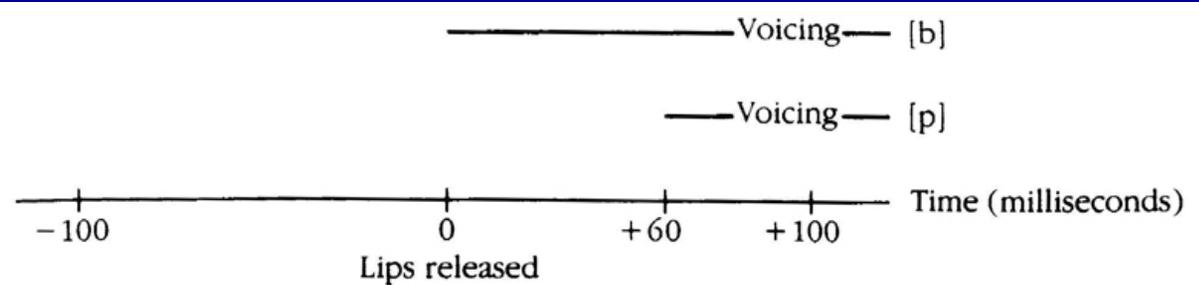


FIGURE 2.19: The difference between [b] and [p], the delay between the release of the lips and voicing in the case of [p]. (From *Psychology and language* by Herbert H. Clark and Eve E. Clark. Copyright by Harcourt Brace Jovanovich. Reproduced by permission of the publisher.)

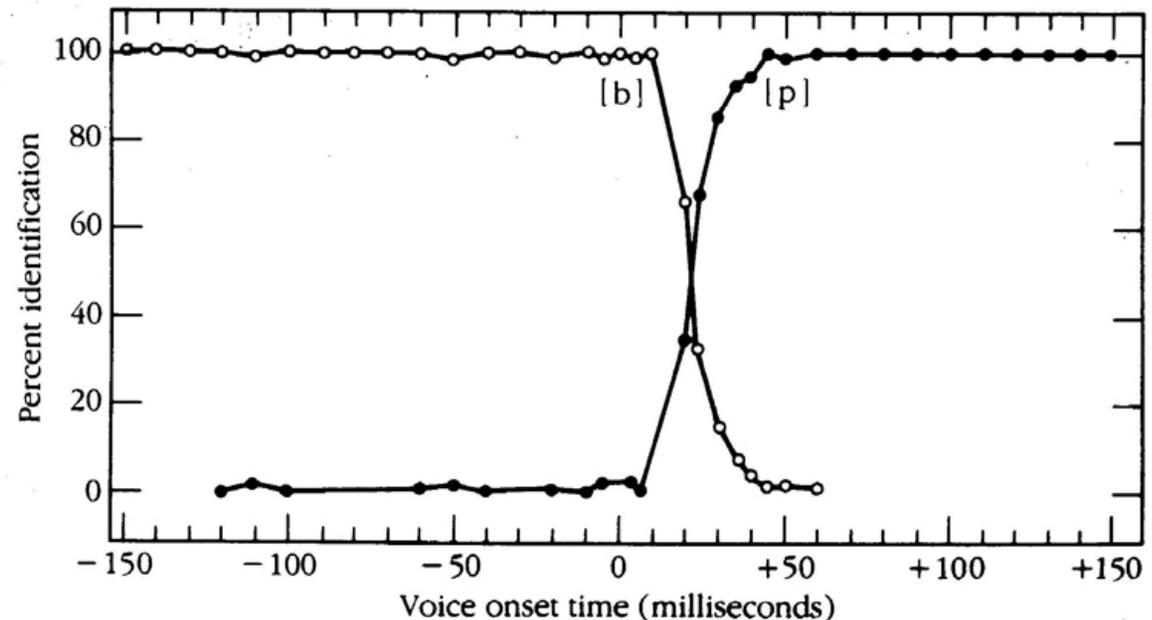


FIGURE 2.20: Percentage identification of [b] versus [p] as a function of voice-onset time. A sharp shift in these identification functions occurs at about 25 milliseconds. (From Lisker & Abramson, 1970.)

SYNTAX

- **structure of sentence**
- **“The model embraced the designer and the photographer**”
- “The model embraced the designer and the photographer laughed.”**

SEMANTICS

- meaning of word or sentence
- *morphemes* are smallest unit of meaning

“Colorless green ideas sleep furiously.”

“Fastly eat dinner, ballgame start soon.”

Semantics/Syntax Interaction

The old man the boats

Semantics/Syntax Interaction

Jay Leno talked about sex with Lindsey Lohan

EVOKED RESPONSE POTENTIALS (ERPS)



Photo courtesy of [squashpicker](#) on Flickr.



- measures changes in electrical activity in msec
- uses surface electrodes placed on the scalp (16-100)
- signal requires a few hundred thousand neurons to fire synchronously
- measures time-locked averages (modest localization)

N400 to Semantic Incongruence

Image removed due to copyright restrictions.
See lecture video.

Reference: Figure 9.30 in Gazzaniga, M., R. Ivry, and G. Mangun.
Cognitive Neuroscience. 2nd ed. W. W. Norton & Co., 2002.

N400 for semantic incongruence (“socks”); P650 for surprise (BIG FONT)

P600 to Syntactic Incongruence

Image removed due to copyright restrictions.
See lecture video.

Reference: Figure 9.32 in Gazzaniga, M., R. Ivry, and G. Mangun.
Cognitive Neuroscience. 2nd ed. W. W. Norton & Co., 2002.

SPS = Syntactic Positivity Shift

PRAGMATICS

- practical understanding
- “Do you know what time it is?” “Yes”
- humor, sarcasm (“Two negatives make a positive, but two positives don’t make a negative.” “Yeah, yeah”)

COMPREHENSION OF AMBIGUOUS WORDS

“bugs”

SEMANTIC PRIMING IN LEXICAL DECISION

Lexical Decision Task

Real word?

DOCTOR
POCTOR
SPY
SYP

CHURCH



DOCTOR

slower

NURSE



DOCTOR

faster

COMPREHENSION OF AMBIGUOUS WORDS

hear

“Rumor has it that for years the government building had been plagued with problems. The man was not surprised when he found several spiders, roaches, and other bugs in the corner of his room.”

After hearing “bugs” see for lexical decision either “ANT” or “SPY” or “SEW”

COMPREHENSION OF AMBIGUOUS WORDS

After hearing “bugs” see for lexical
decision

<u>Word</u>	<u>Delay</u>	<u>Response</u>	<u>Delay</u>	<u>Response</u>
“ANT”	500 msec	- fast	2000 msec	- fast
“SPY”	500 msec	- fast	2000 msec	- slow
“SEW”	500 msec	- slow	2000 msec	- slow

Exhaustive lexical access - all
meanings are activated, correct one is
maintained, incorrect one is
suppressed

PRAGMATICS

- practical understanding
- “Do you know what time it is?” “Yes”
- humor, sarcasm (“Two negatives make a positive, but two positives don’t make a negative.” “Yeah, yeah”)
- emotional intonation & right hemisphere



Public domain image.

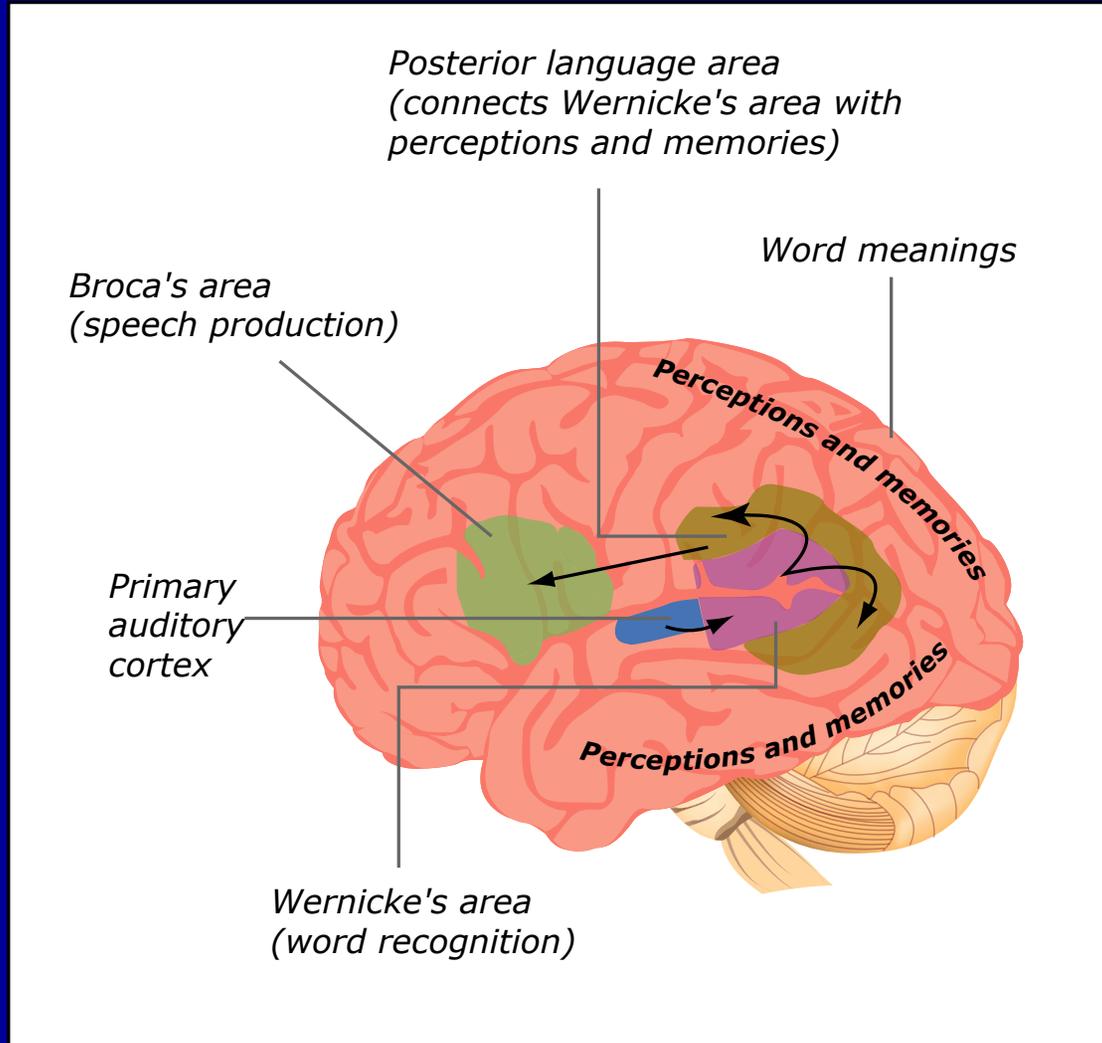
SUPERIOR IDENTIFICATION OF LIES BY PATIENTS WITH LEFT HEMISPHERE LESIONS

Table 1 Success in interpreting lying cues

Group	Vocal pitch cues only	Facial expression cues only	Facial and vocal cues
LH	0.30	0.73	0.60
RH	0.20	0.50	0.45
C	0.20	0.57	0.47
UC	0.32	0.50	0.47

Values represent proportion correctly identifying liars. LH, left-hemisphere-damaged aphasics, mean age 58.4 years, patients at the Massachusetts General Hospital who gave informed consent. Their diagnoses, based on neurological examinations and MRI, were left middle cerebral artery infarct (nine patients) and subarachnoid haemorrhage (one subject). Neuropsychological testing revealed at least low average intellectual and perceptual abilities. Subjects achieved 95% correct (87.5–100% range) on a word-to-picture matching task and 89% correct on a lexical decision task (78–94% range)¹, indicating recognition of single words. However, they performed at near-chance levels on a sentence-to-picture matching task, with an average accuracy of 58% (53–69% range)², suggesting severely compromised comprehension of sentences. RH, right-hemisphere-damaged patients, mean age 59.6 years. C, matched controls, mean age 60.2 years. Both RH and C groups had equal numbers of men and women, were matched with the LH patients for education and IQ scores, were patients at the Massachusetts General Hospital, and had given informed consent. UC, undergraduate controls.

The Neural Basis of Human Speech



Broca's aphasia & Wernicke's aphasia

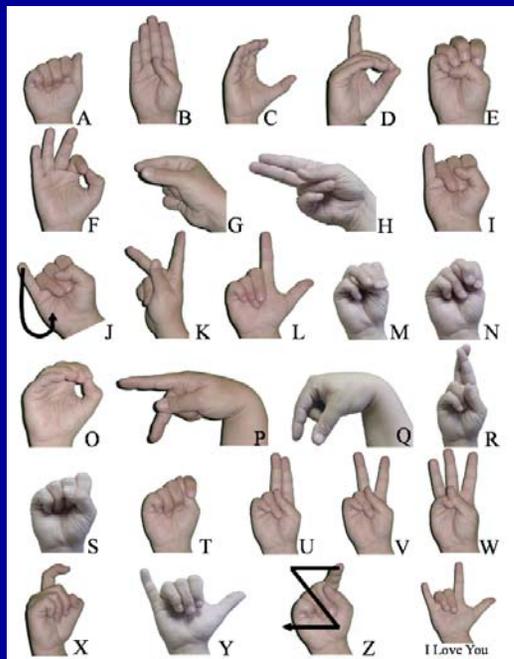
	<u>Broca's</u>	<u>Wernicke's</u>
<i>Lesion</i>	frontal	temporal
<i>Speech</i>	nonfluent, telegraphic paraphasia, empty	fluent, empty
<i>Comprehension</i>	good	poor

COOKIE-THEFT PICTURE

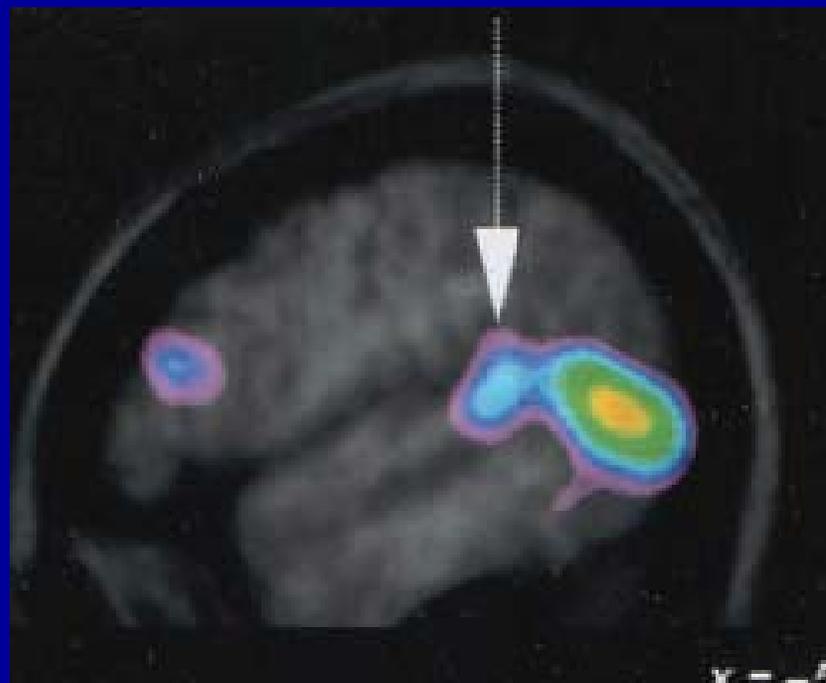


Source: Boston Diagnostic Aphasia Examination (BDAE). © Pearson. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/fairuse>.

Neural Basis of Language



Public domain image.



Courtesy of National Academy of Sciences, U.S.A. Used with permission.
Source: Petitto, L. A., et al. "Speech-Like Cerebral Activity in Profoundly Deaf People while Processing Signed Languages: Implications for the Neural Basis of Human Language." *PNAS* 97, no. 25 (2000): 13961-6.
© 2000 National Academy of Sciences, U.S.A.

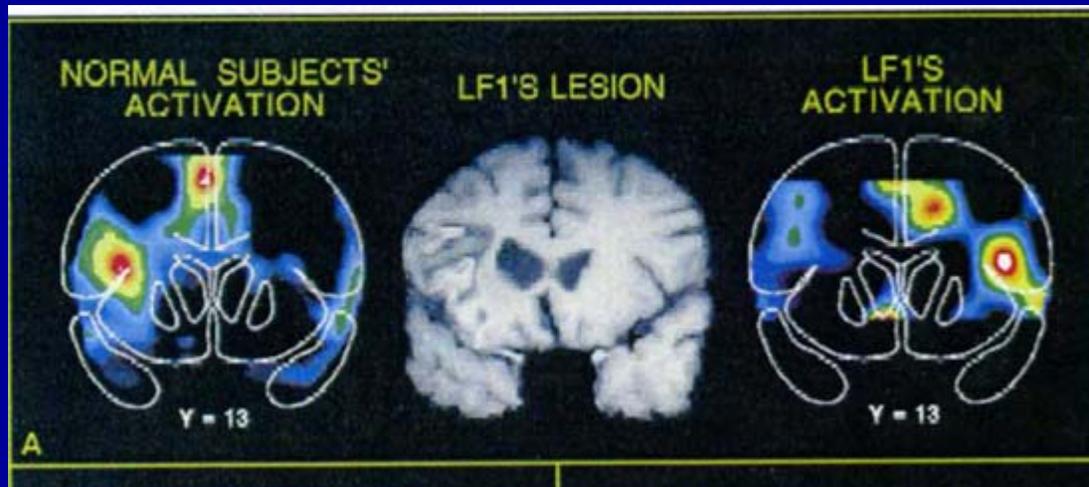
**Regardless of modality, sign & speech,
recruit Wernicke & Broca regions;
Deaf infants “babble” with their hands**

- language is separable from speech

Petitto et al,
PNAS (2000)

Recovery in Aphasia reflects right-hemisphere participation in language

Case study – left frontal injury – word stem completion (name a word that starts with STA____) activates right frontal region, compared to normal left frontal region



Courtesy of National Academy of Sciences, U.S.A. Used with permission. Source: Buckner, R. L., et al. "Preserved Speech Abilities and Compensation Following Prefrontal Damage." *PNAS* 93, no. 3 (1996): 1249-53. © 1996 National Academy of Sciences, U.S.A.

Language Acquisition



Photo courtesy of pohly on Flickr.

Major Milestones in Language Acquisition

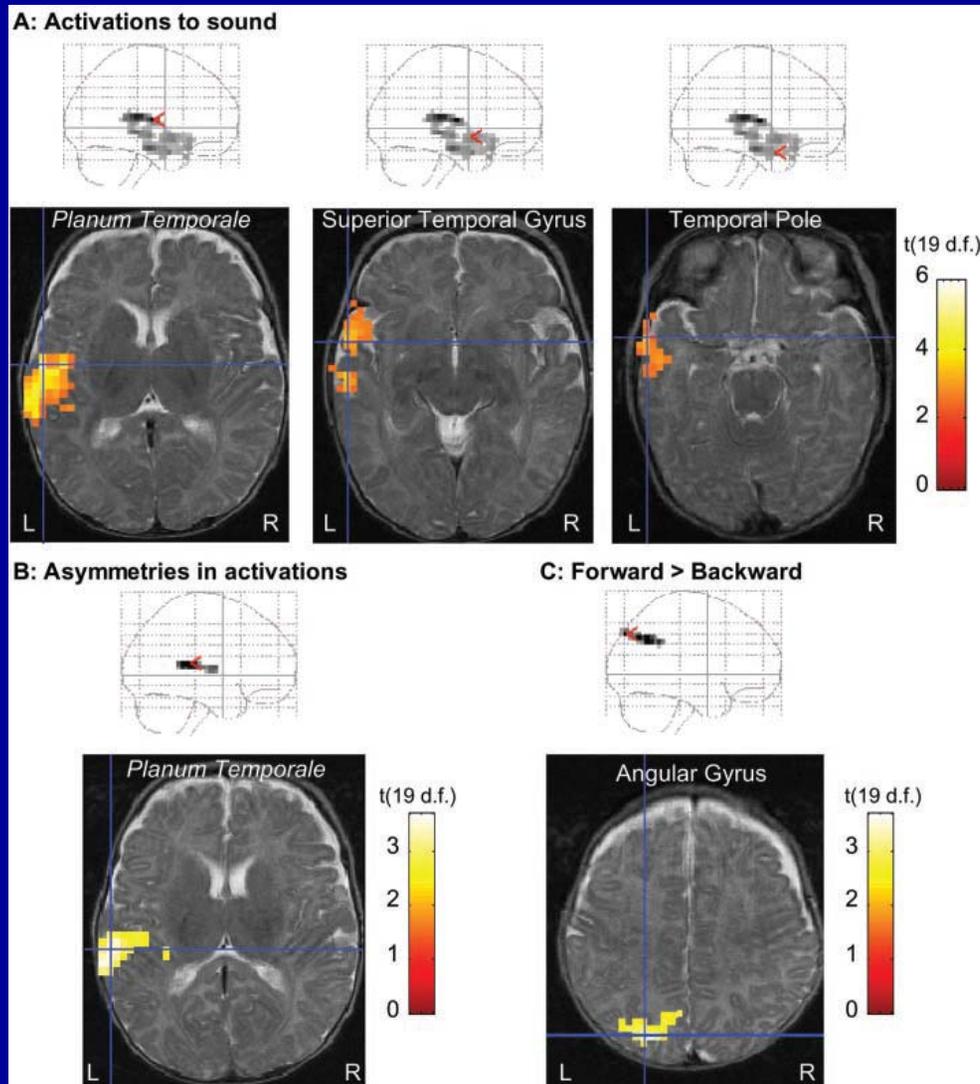
Approximate age	Major Linguistic Development
2-3 Months	Perceive all phonemes; notice changes in phonemes
6 Months	Ignore distinctions between sounds not used in languages spoken around them; babbling begins
8 Months	Identify words in the continuous speech stream
1 Year	Babbling has adultlike intonation patterns; speaking begins
13 Months	Understand about 50 words
18 Months	Speak about 50 words
2 Years	Telegraphic speech
3 Years	Simple pragmatics
4 Years	Rules of grammar, such as plural
6 Years	Know about 10,000 words
9 Years	Subtle pragmatics

Image by MIT OpenCourseWare.

INFANTS & LANGUAGE

- sucking on a nipple (rate)/habituation
- within 2 hours of birth, chose mother's voice over another voice (had not heard mother after birth)
- 3-day olds preferred language to other sounds like music
- 4-day olds noticed French/Dutch distinction
- 2 months phonemic distinctions (ba/ga), preference for own language

2-Day Old Infants Show Left Hemisphere Specialization for Speech



MOTHERESE

- child-directed speech
- short, pauses, careful enunciation, exaggerated intonation in high pitch
- fits perfectly with infant perception



Photo courtesy of tomhe on Flickr.

CATEGORICAL PERCEPTION

NON-NATIVE LANGUAGES

6-12 MONTHS (Werker & Lalonde 1988)

Ba Ba Ba Da Da Da Da Da

Eng Infants

10-12 mos

Eng Adults



Ba Ba Ba da da Da Da Da

Eng Infants

6-8 mos

Hindi Adults

16 Equal Steps from BA to DA

Categorical Perception

Phoneme categorical perception (e.g., ba/da)

Universal “learner” up to 8 months

Native “learner” = 12 months



Courtesy of Janet Werker. Used with permission.

Behavioral Evidence:
Head Turn Procedure
in Speech

<http://www.youtube.com/watch?v=Ew5-xbc1HMk>

Werker & Tees, 1992

Are Bilingual Children Delayed & Confused?

Babies “absorb” language easily!

BUT.... Isn't 2 languages an overload?



THOUGHTS?

Photo courtesy of pohly on Flickr.

Bilingual Language Development

Language Delayed? NO!

Bilingual Groups - English/French, English/ASL, French/LSQ (ages 0-3) (Petitto & Kovelman, 2003; Petitto et al., 2001)

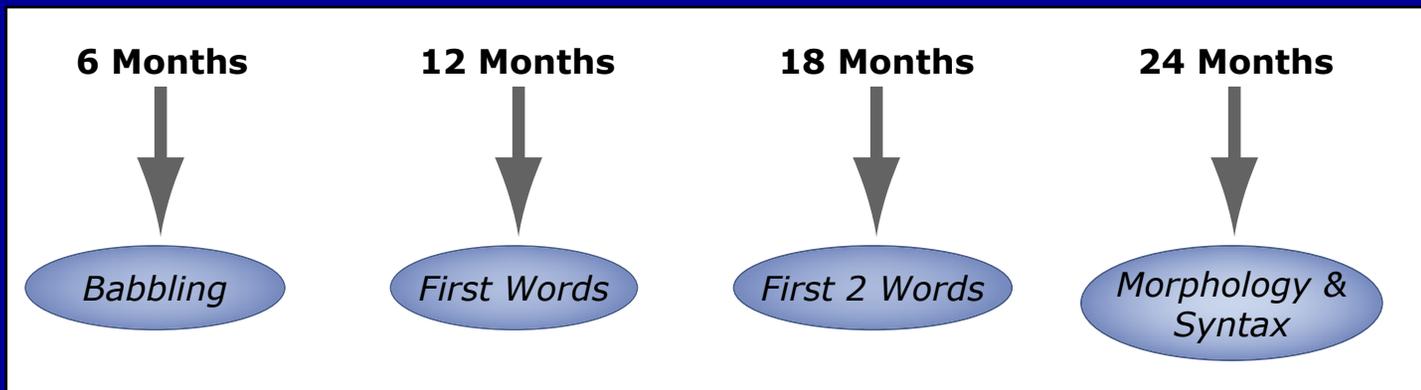
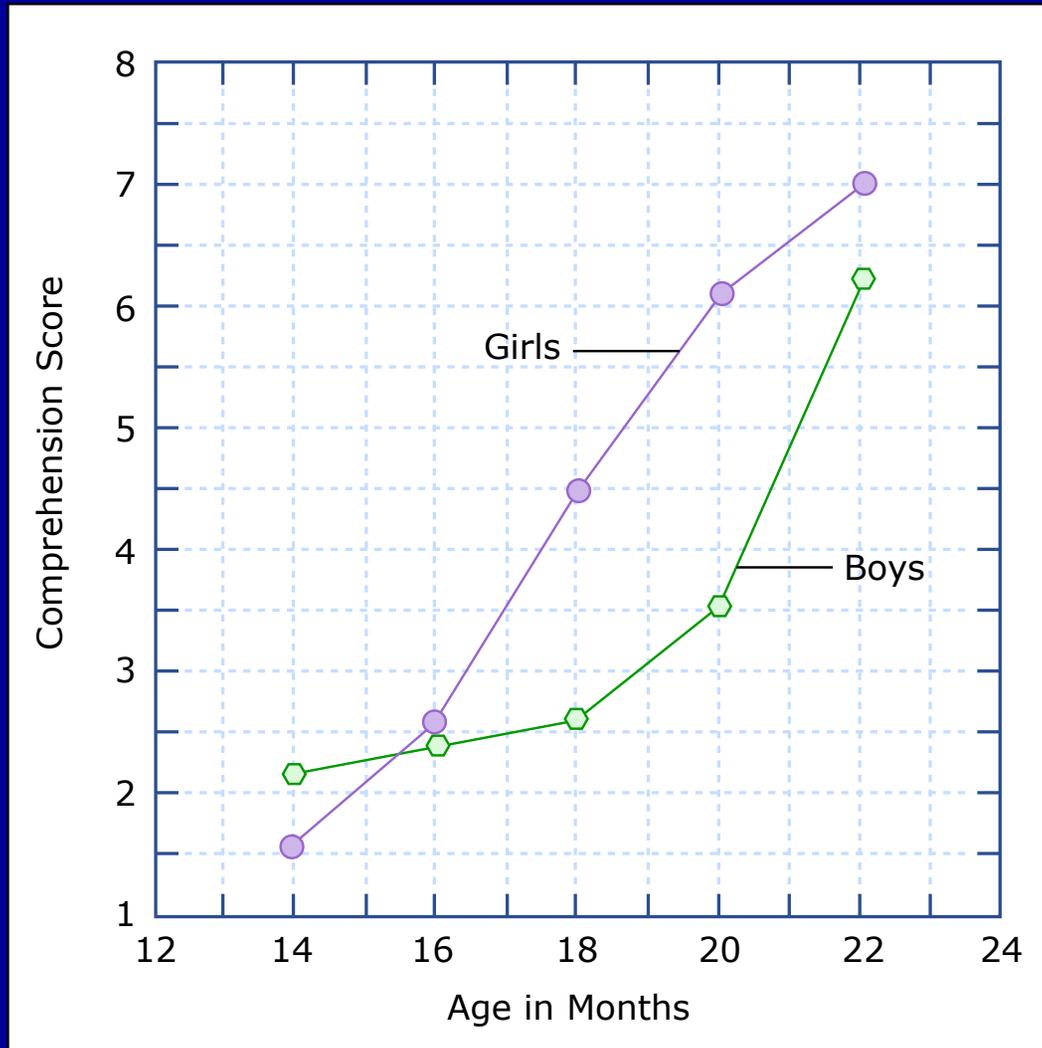


Image by MIT OpenCourseWare.

The Number of New Words Understood During the First Two Years of Life



Critical Period in Language Acquisition

Fragile & Resilient aspects of language

FRAGILE – phonology (production) & grammar
- age sensitive

RESILIENT - semantics/vocabulary learning -
can be easily learned later in life

Critical Periods in Second Language

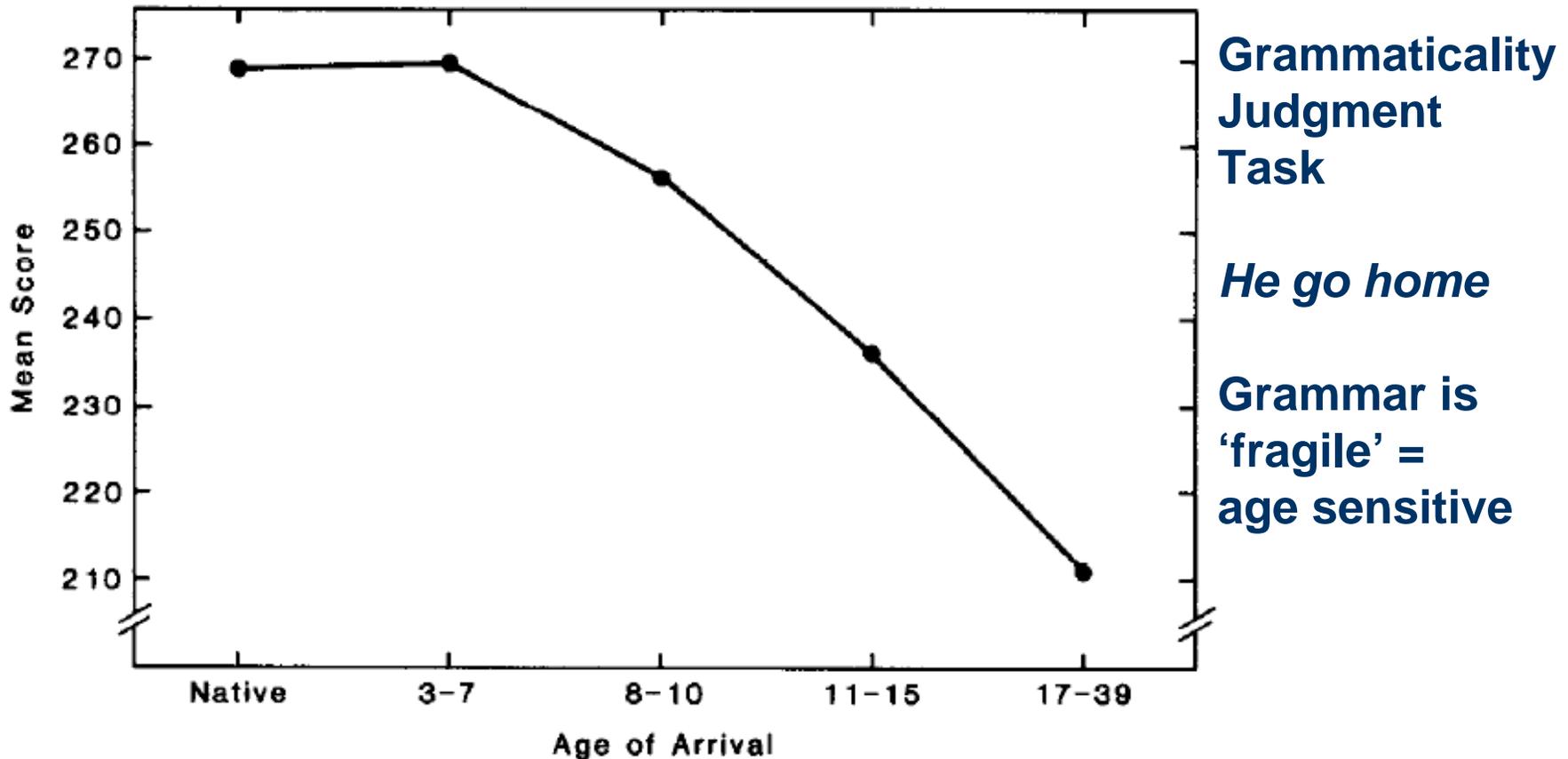


FIG. 1. The relationship between age of arrival in the United States and total score correct on the test of English grammar.

Source: Johnson, J. S., et al. "Critical Period Effects in Second Language Learning: The Influence of Maturational State on the Acquisition of English as a Second Language." *Cognitive Psychology* 21 (1989): 60-99. Courtesy of Elsevier, Inc., <http://www.sciencedirect.com>. Used with permission.

CRITICAL PERIOD?

Genie - locked in back room from 20 months until 13 years of age

Class watches 7:00 video clip from Secret of the Wild Child. PBS/NOVA, 1994.

1:30

36:30

46:40

MIT OpenCourseWare
<http://ocw.mit.edu>

9.00SC Introduction to Psychology
Fall 2011

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.