LANGUAGE

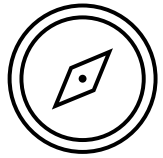
http://svg-whiz.com/svg/linguistics/theCreepyMouth.svg

https://sail.usc.edu/span/rtmri_ipa/pk_2015.html

Announcements

- Study guide available later today
  - Will include questions from the optional quizzes (will add q's from quiz 4 later)
- Extra drop-in office hours in Uris Hall room 230
  - Thursday (today) 4-5 pm & Friday 1:30-2:30 pm
- MRI Facility Tours! (extra credit)
  - April 16th and April 23rd 3-4 pm
  - Space is limited - I will distribute a sign-up form
- Optional Final Exam: 5/17/25 @ 2 pm

The plan



- How are sounds linked to meaning?
- What are the phonemes? Words?
  - Auditory processing
  - Visual & motor integration
  - What about visual symbols?
- Hierarchical structures and prediction
- How does one get to meaning?

From Sounds to Words ("What" and "How")

The Parts of Speech (Phonemic Invariance)

- Phonemes: the smallest unit of sound that distinguishes one word from another
  - cat/bat/mat/sat/rat/fat/tat/pat
  - pup/pep/pop

THE INTERNATIONAL PHONETIC ALPHABET (revised to 2005)

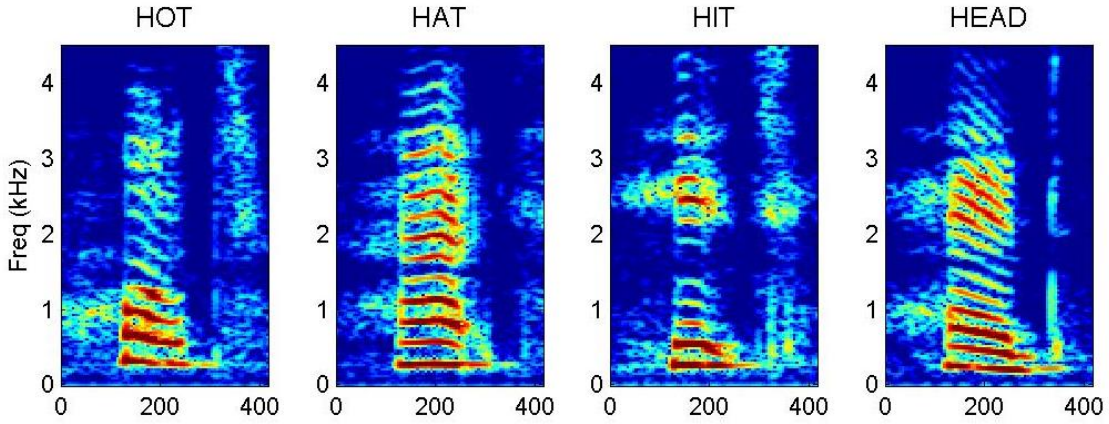
CONSONANTS (PULMONIC) © 2005 IPA

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k g	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	N		
Trill	B			r					R		
Tap or Flap		ⱱ		ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

- Invariants: regularities encountered over different contexts

- Distinguish in a spectrogram?



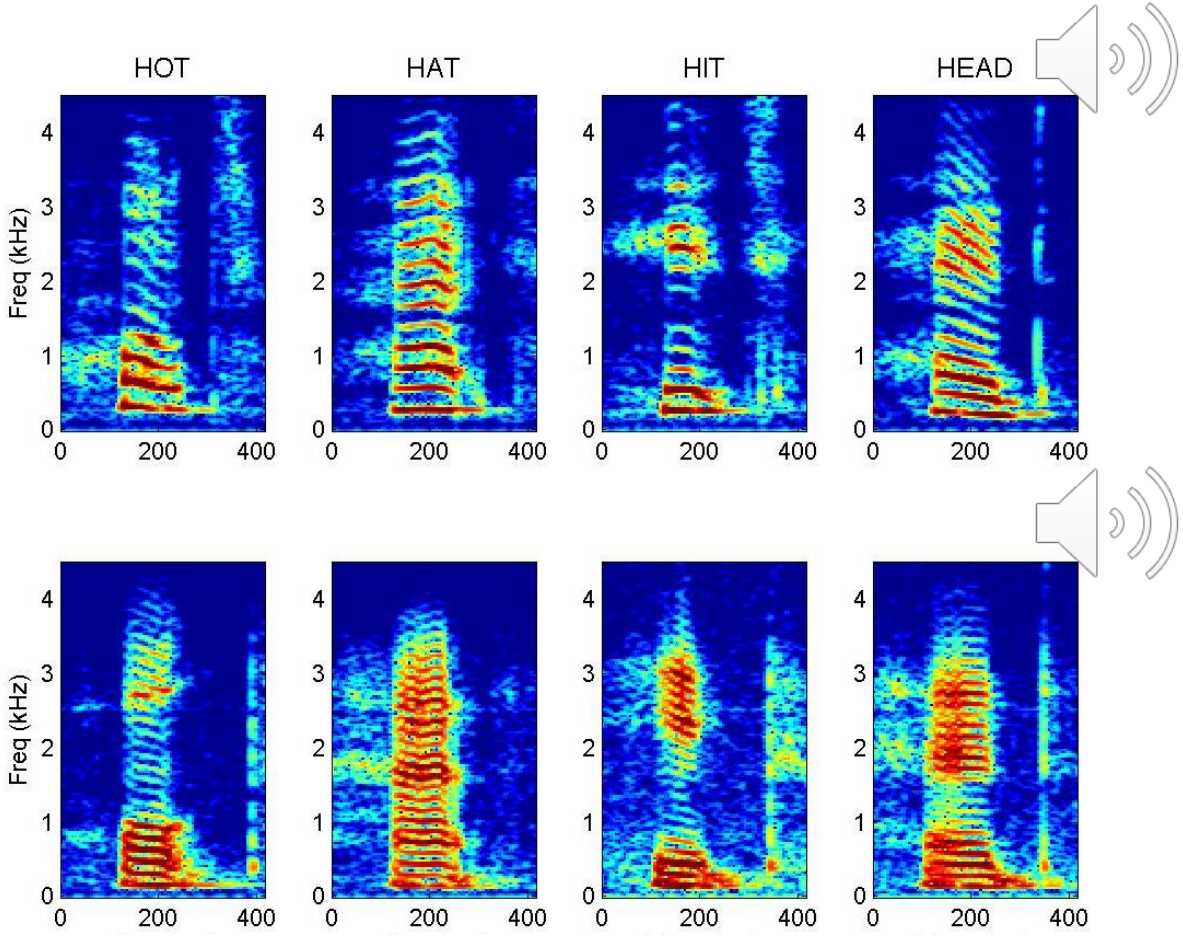
http://www.phonetics.ucla.edu/course/chapter8/8.3.htm

https://auditoryneuroscience.com/topics/formants-and-harmonics-spoken-vowels

The Parts of Speech (Phonemic Invariance)

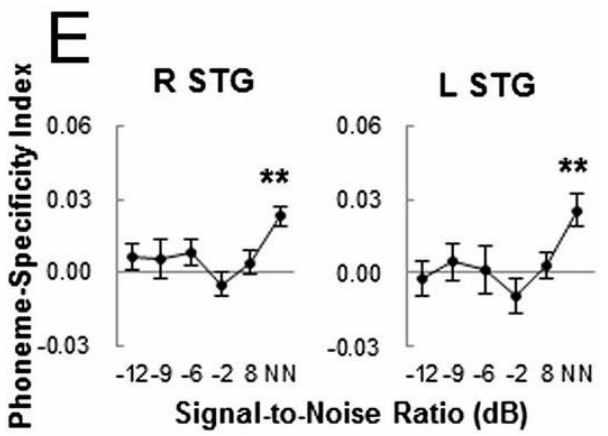
- Variable acoustic signal mapped to invariant representation of a phoneme

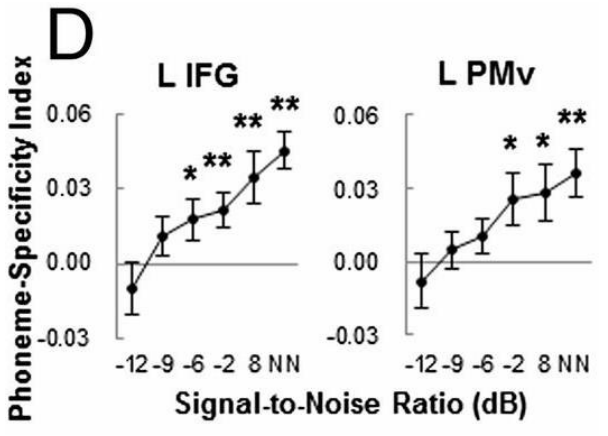
- Varies across
  - Individuals
  - Speed
  - Emotion
  - Coarticulation

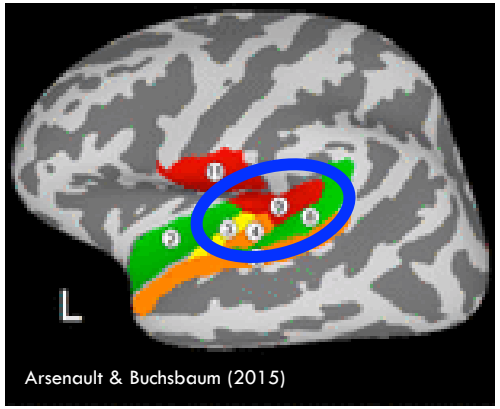


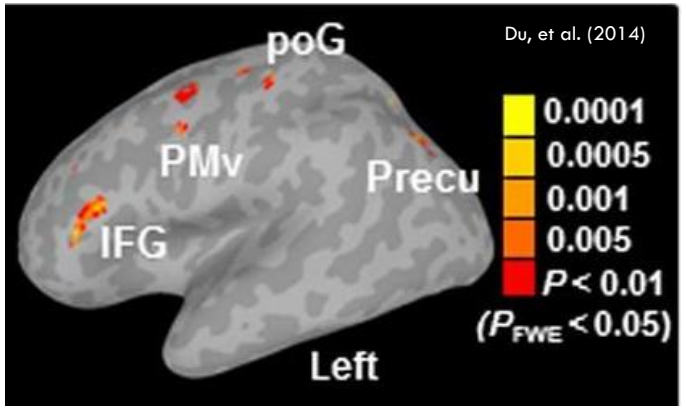
The Parts of Speech (Phonemic Invariance)

- Left and right STG distinguish phonemes
  - Phoneme specificity
- Basal ganglia connectivity
  - Supports learning
- Motor regions contribute
  - Left IFG and left ventral Premotor
  - More noise tolerant than auditory areas
  - More when when needed









Based on what we learned about the motor system, what is a likely role of ventral premotor cortex in speech?

- Sequencing movements
- Executing the muscle movements
- Integrating visual and auditory information
- Selecting movements for articulation

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Sequencing movements

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Executing the muscle movements

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Integrating visual and auditory information

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Selecting movements for articulation

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Selecting movements for articulation

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What about co-articulation?

- Motor Theory of Speech Perception

- Speech sounds are mapped to movements used to produce them
  - Articulatory gestures
  - Evidence: e.g., reading times slower for harder to pronounce words; seeing helps comprehension

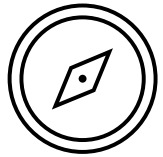
- Can "perceive" co-articulation and adjust for that

- But, controversial

https://sail.usc.edu/span/rtmri_ipa/pk_2015.html

https://upload.wikimedia.org/wikipedia/commons/9/9f/Real-time_MRI_-_Speaking_%28English%29.ogv

Challenges in Speech Perception



- Ambiguity (one-to-many)
- Invariance (many-to-one)
- Context & expectancies
- AND segmentation

- Integrate knowledge with sensory and motor systems
  - Similarities to visual recognition
  - Hierarchical (later)
  - Time sensitive (later)

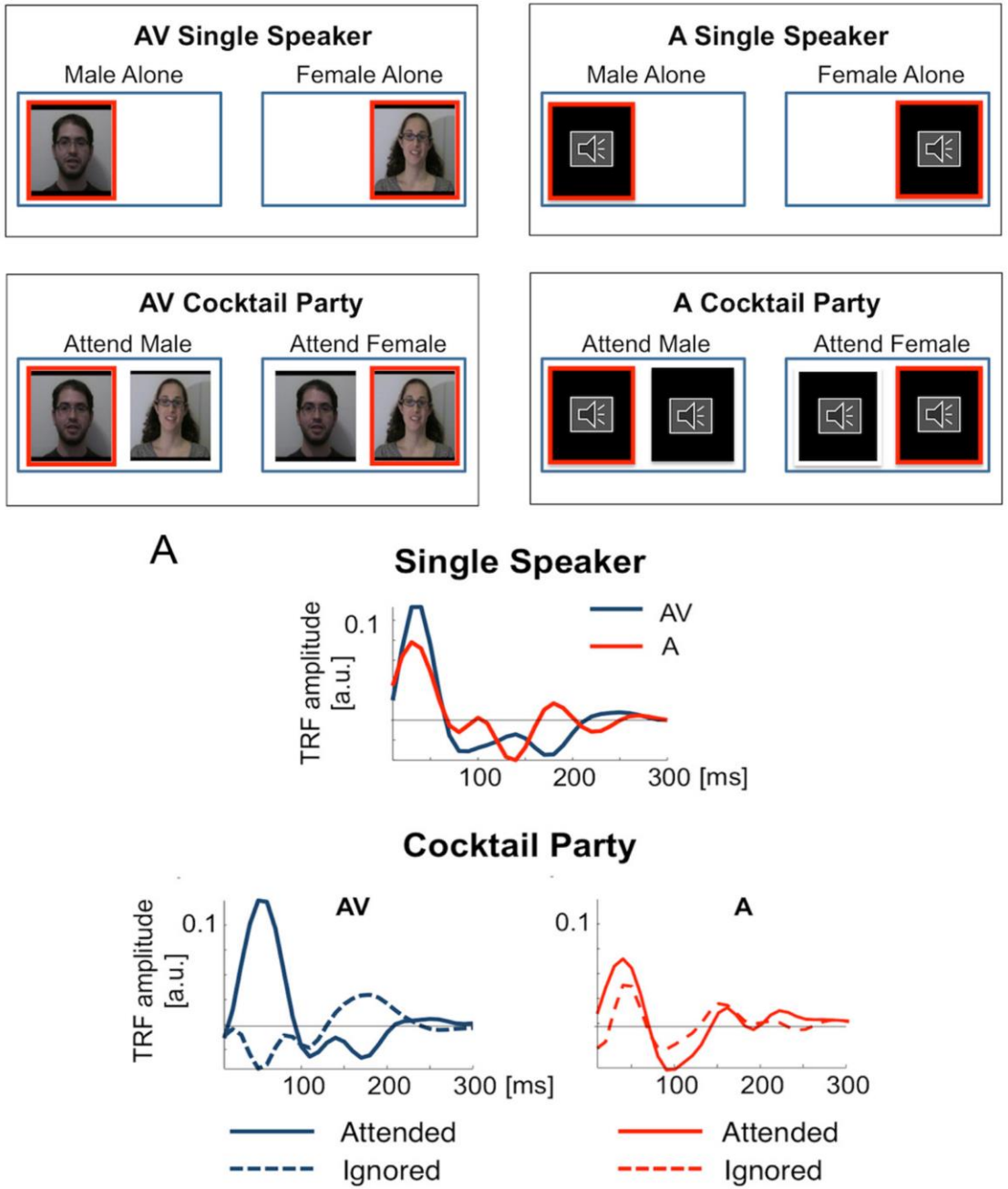
An illusion

- The McGurk Effect

Help From the Visual System

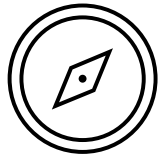
- Vision aids auditory speech perception
  - Magnetic Encephalography (MEG)
  - How late are frequencies in auditory cortex relative to frequencies in speech?
  - Faster match when visual info is present
  - Especially when there are multiple speakers

- Multi-modal integration in early perceptual areas



Zion Golumbic, et al. (2013)

Challenges in Speech Perception



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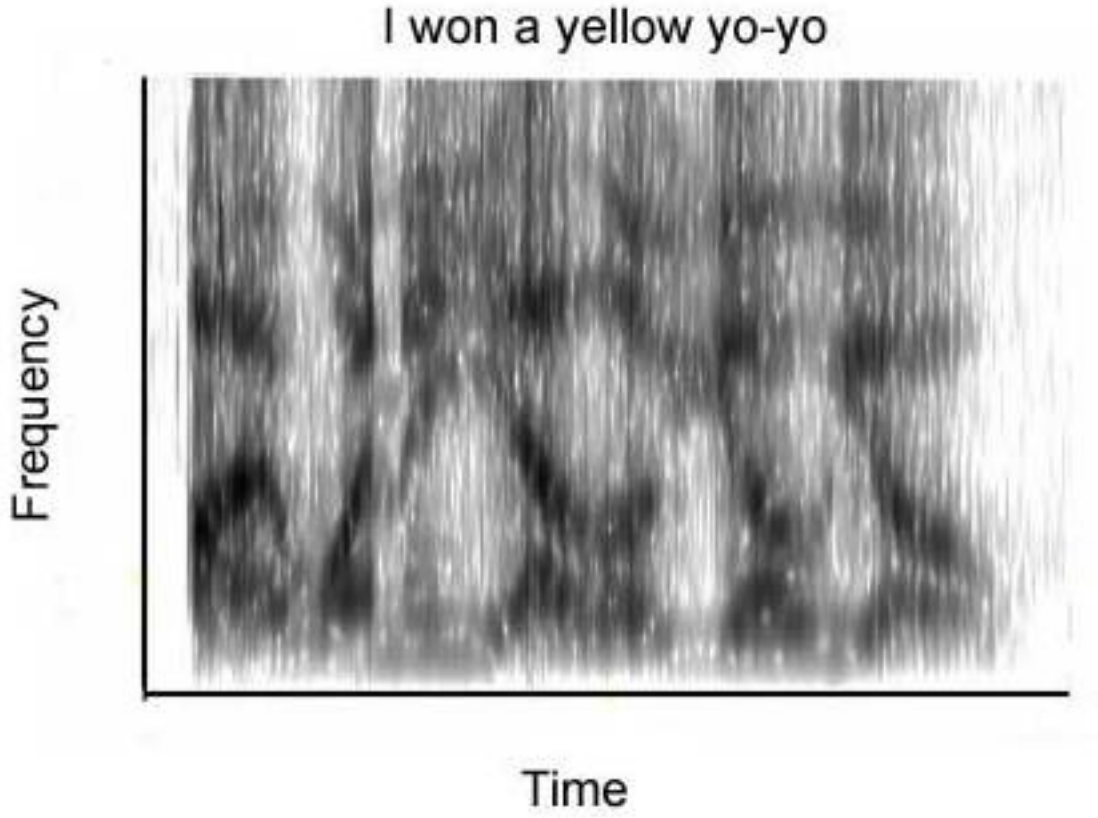
Speech Signal is Continuous



- How is continuous speech divided into useful parts?
- **Segmentation**: Divides continuous speech signal into words

http://pip.ucalgary.ca/psyc-369/mod6-hearing/unit6.3-the-perception-of-speech-and-music/Stimulus-Problem.html

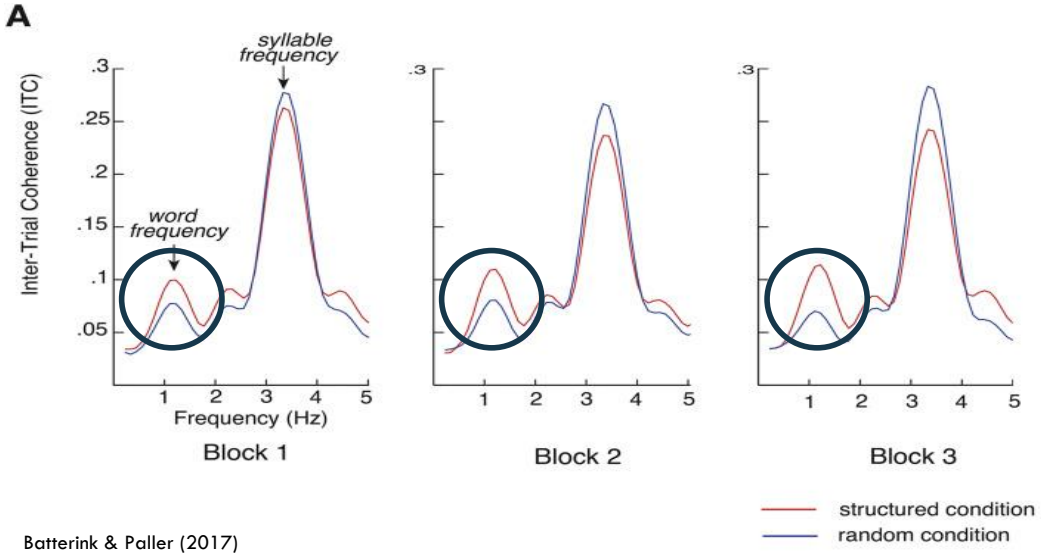
Statistical Learning

- People (babies) learn sequences of phonemes

bidakupadotigolabubidakutupiropadoti

bidakupadotigolabubidakutupiropadoti

- EEG: With learning, brain rhythms synced to ends of sequences



Batterink & Paller (2017)

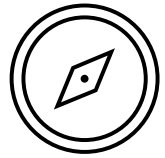
One way that words may be segmented

Take-aways

- The speech signal can be *ambiguous,* variable (*invariance*), context dependent, and unsegmented (continuous)

- The brain…
  - Maps variable speech signals to invariant phonemes
  - Segregates auditory speech processing into how and what
  - Integrates auditory, visual, and motor/articulatory information
  - Utilizes statistical info to identify invariant chunks (words)

The plan

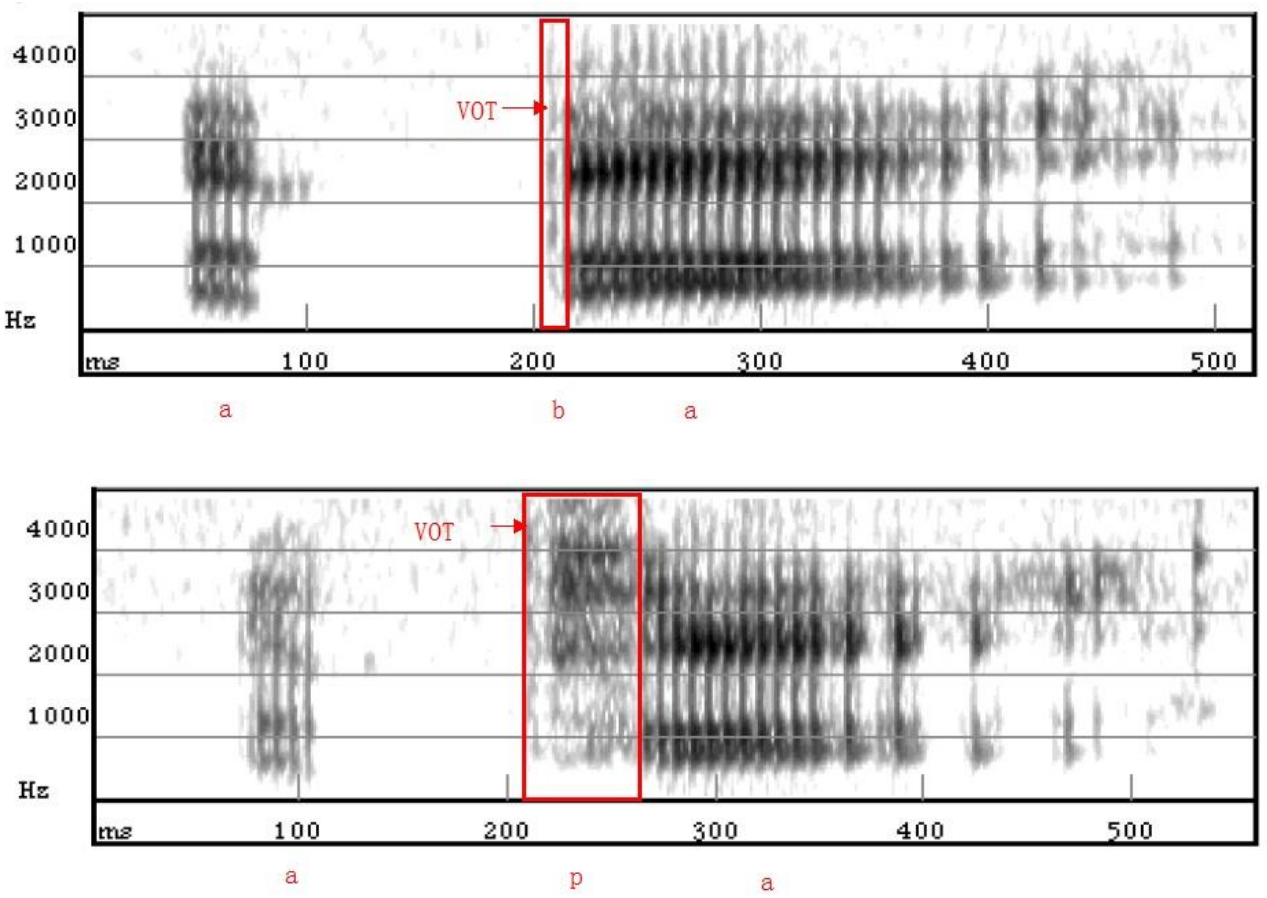


- Overall: How are sounds linked to meaning?
- What are the phonemes? Words?
  - Auditory processing
  - Visual & motor integration
  - Statistical learning
- Hierarchical structures and prediction
- How is meaning represented in the brain?

Hierarchical & Predictive Processing

Time scales in linguistic processing

- Temporal constraints
  - Voicing: 10s of ms
  - Syllables: hundreds of ms
  - Words: seconds
  - Sentences…
  - Paragraphs…
  - Narratives…
- How does the brain do this?
  - Integration over time
  - Predictive context…



For fun, check out: https://wstyler.ucsd.edu/posts/scuse_me.html

https://corpus.eduhk.hk/english_pronunciation/index.php/3-2-acoustic-aspects-of-consonants/

Which of the following is true? Neurons in the ventral visual stream that have relatively large receptive fields

- are found in V1 rather than inferior temporal cortex
- also tend to code more abstract/complex info
- represent a smaller portion of the visual field
- are primarily involved in representing edges

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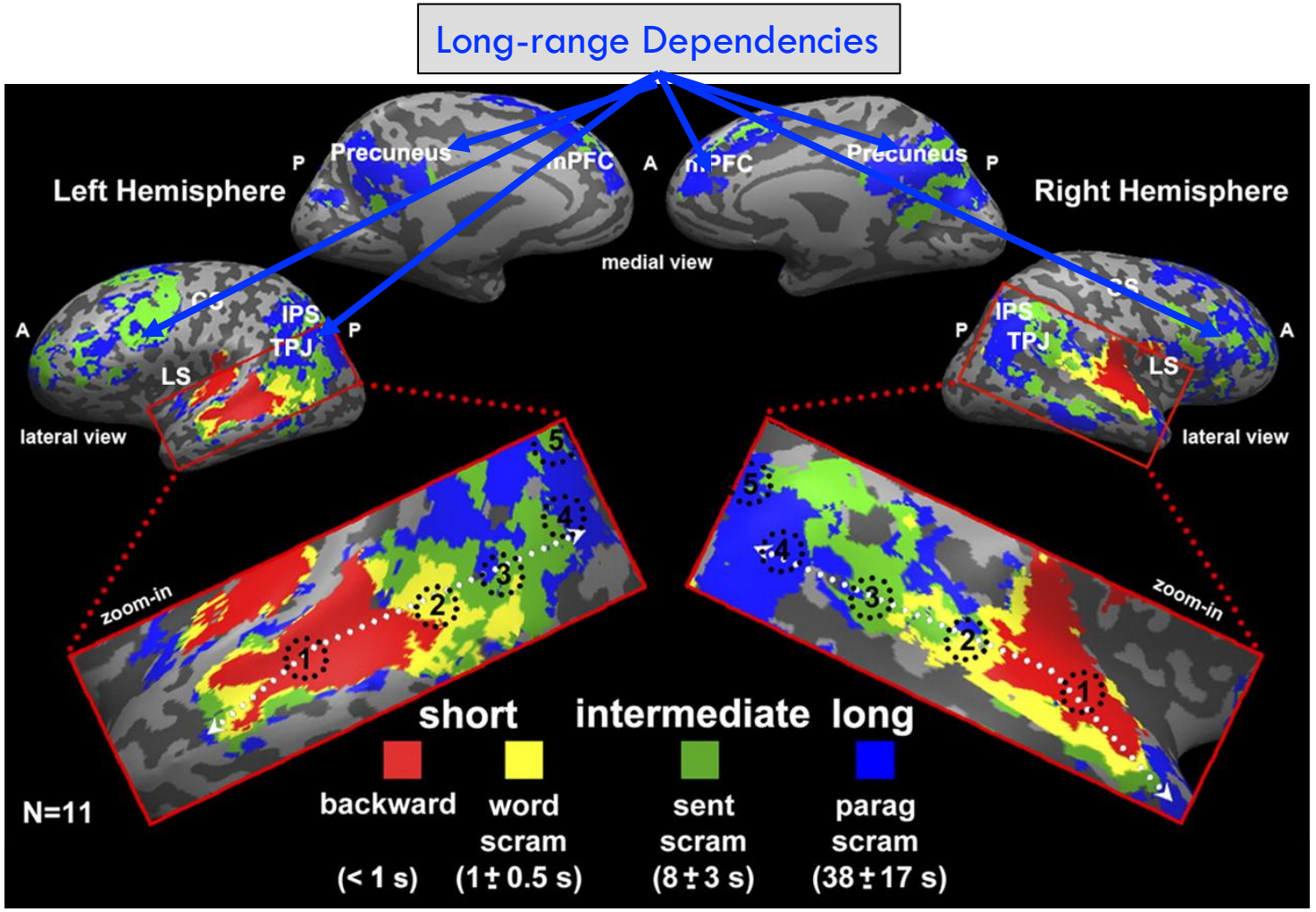
0%

Time scales in linguistic processing

- Speech info changes over different time scales

- Auditory speech processing is hierarchical
  - Phonology to narrative
  - Short & simple in A1, A2
  - Longer and more complex as move away



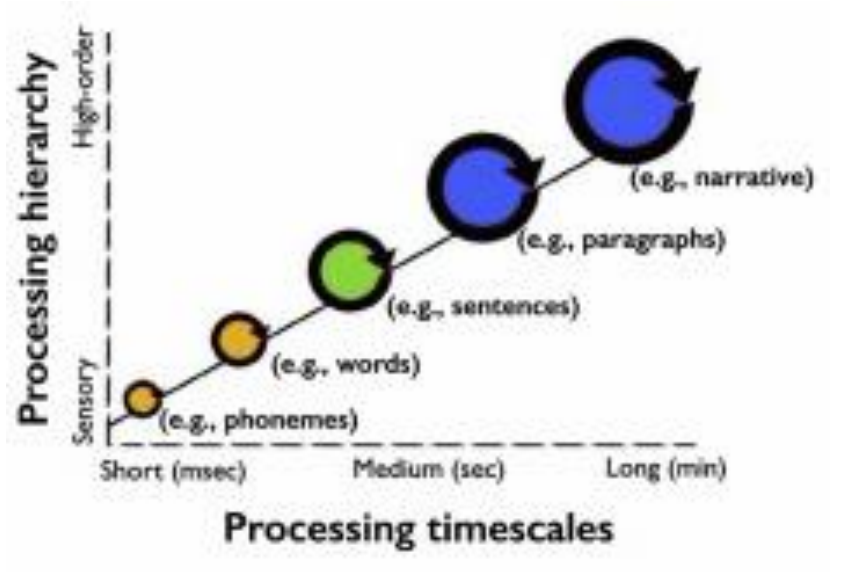
Lerner, et al. (2011)

Time scales in linguistic processing

- Speech info changes over different time scales

- Auditory speech processing is hierarchical
  - Temporal receptive window
  - Increases as move away from primary sensory cortex
  - Both dorsal and ventral

- Similar in visual processing



Hasson, et al. (2015)

Longer time scales may influence what you hear

- Which phoneme is missing?


- Perceive the /s/ even though it's been replaced by the cough

- Phonemic Restoration

http://sites.sinauer.com/languageinmind/wa07.08.html