The Neural Basis of Language

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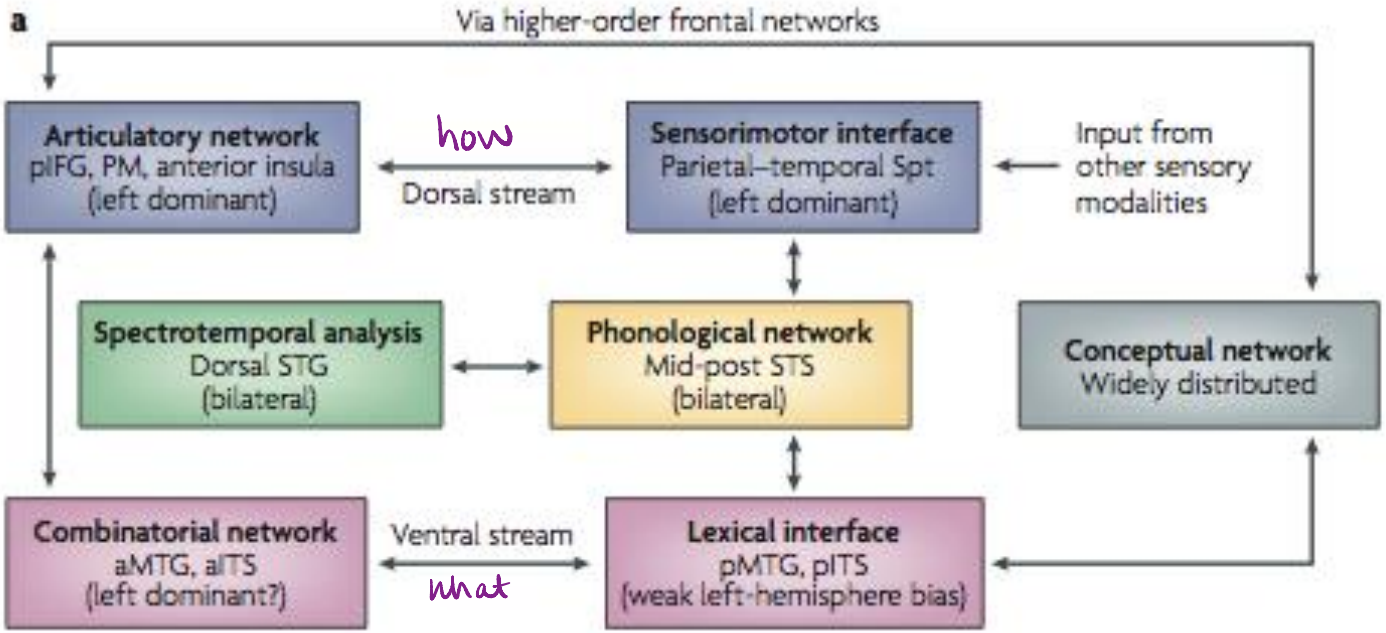
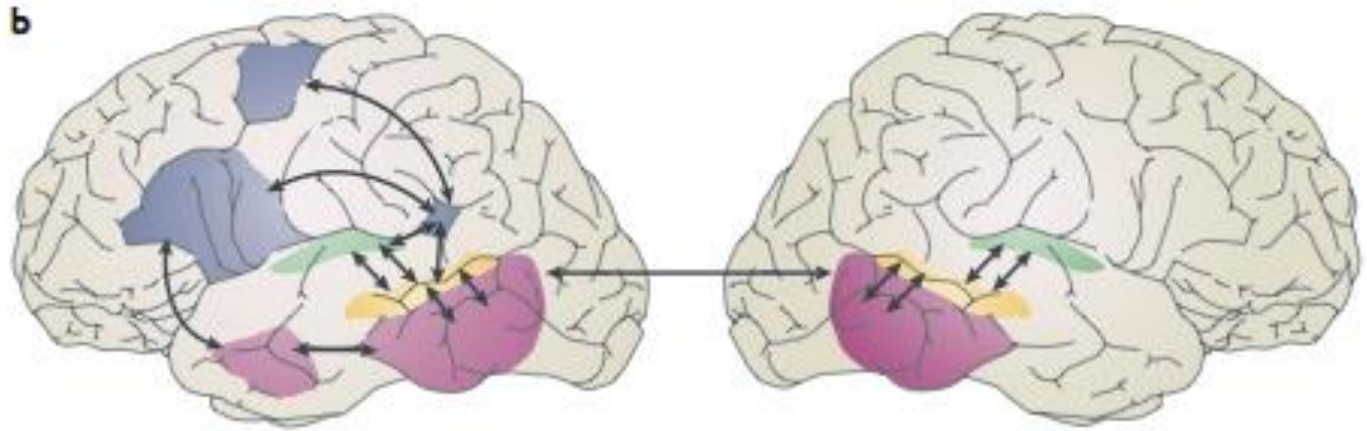
Main Points

- Speech perception
  - Experienced interpretation
- Speech production
  - Interactive, distributed, hierarchical
- Sensorimotor integration
  - adaptive plasticity & reactivation
- Meaning
  - words, concepts, & perceptual experience

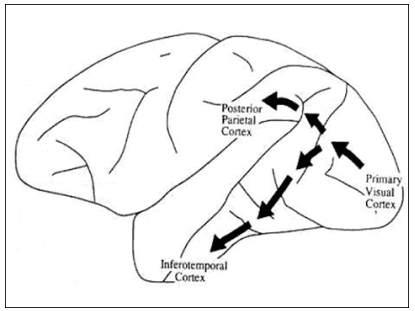
Parallels to other systems

A Model of Speech Perception





Hickok G, Poeppel D (2007) The cortical organization of speech processing. Nat Rev Neurosci 8:393-402.

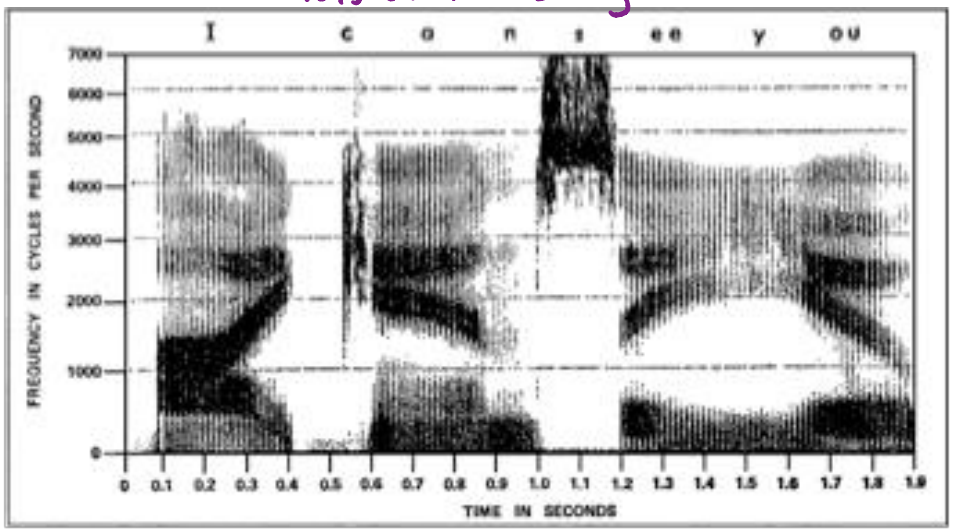


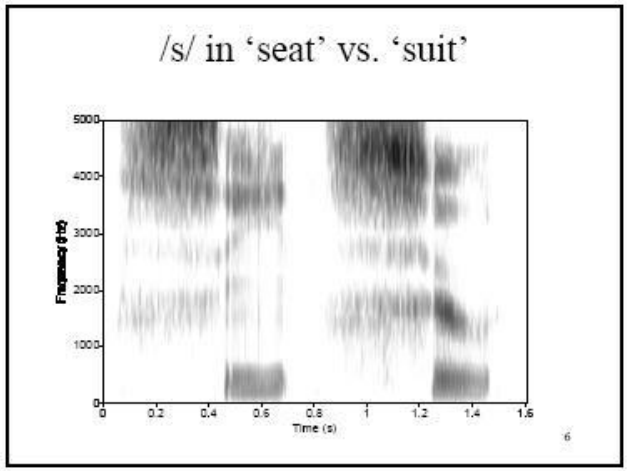
linguistics: building blocks of sound
phony

Speech as Experienced Perception

Acoustic input → words

lots of variability

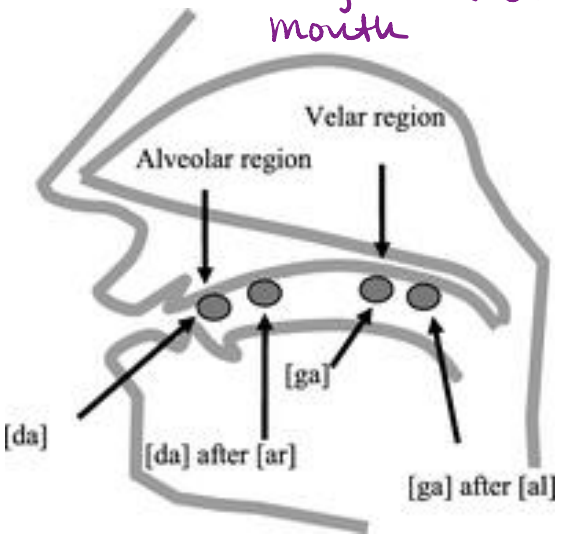


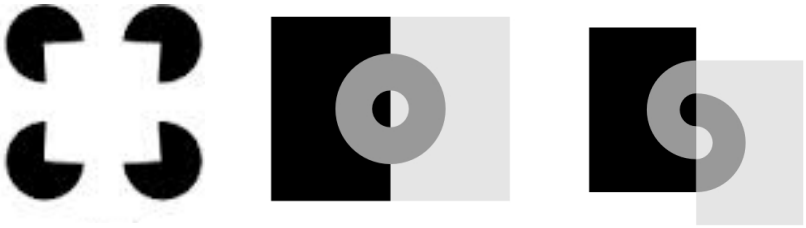


Spectrograph:
freq vs. time

Speech = phony + context

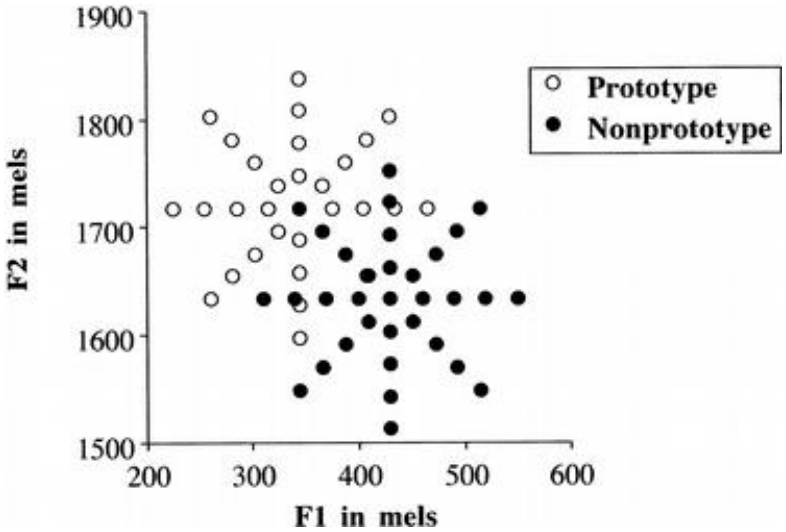
Configurations of mouth



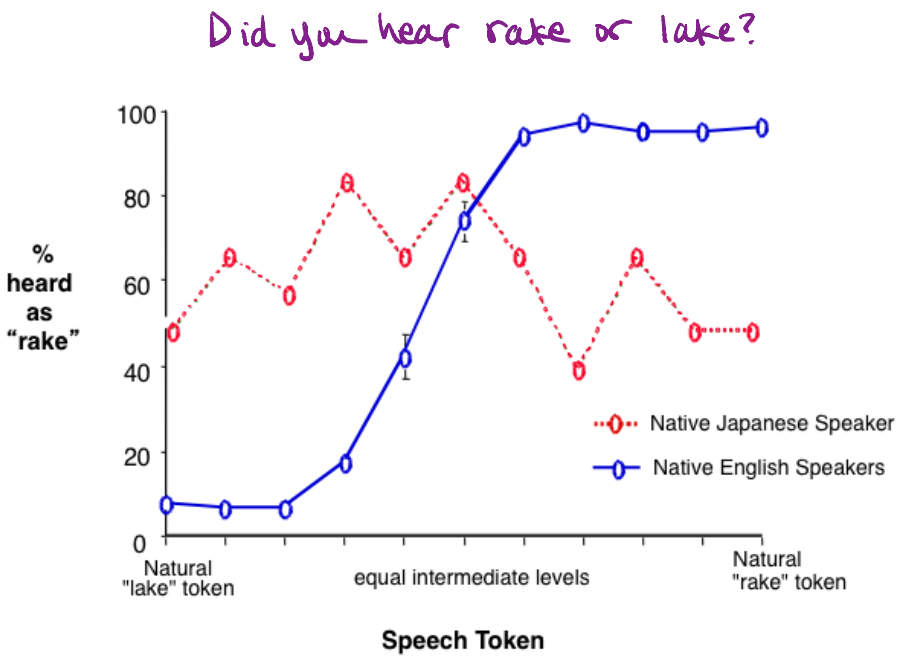


Categorical Perception

Theory



Data



McCandliss et al. (2002), CABN, 2:89-108.

perceptual magnets

Tuning for Speech Perception

Changes in discrimination:

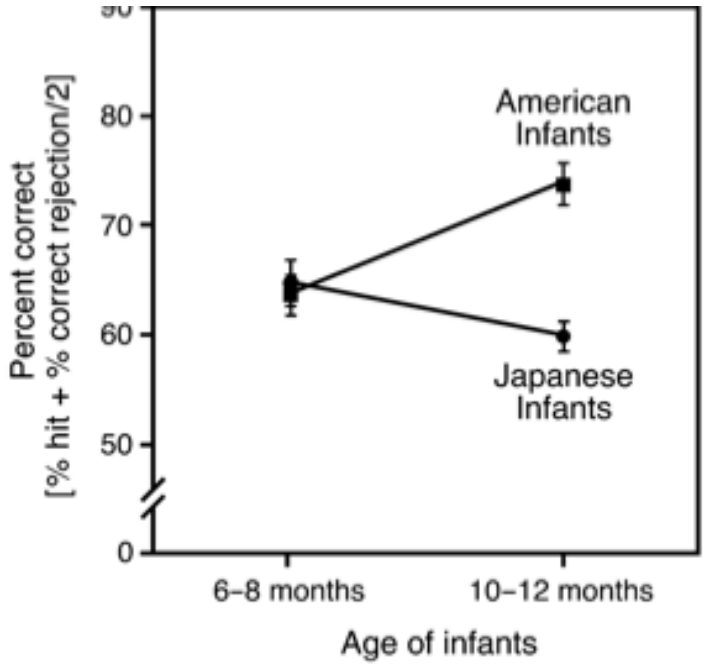
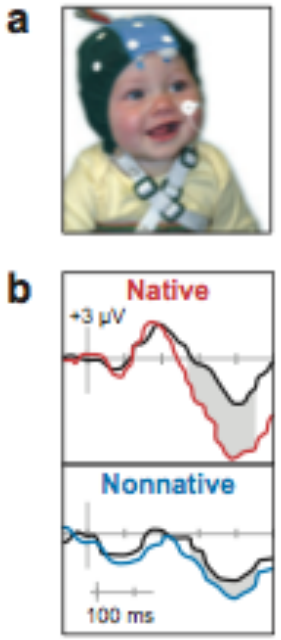


Figure 1 *Effects of age on discrimination of the American English /ra-la/ phonetic contrast by American and Japanese infants at 6–8 and 10–12 months of age. Mean percent*

Changes in ERP signature:



Babies orient to novel sounds
(universal listeners)

Kuhl et al. (2006), Dev Sci, 9:F13-F21.

Kuhl & Rivera-Gaxiola (2008), Ann Rev Neurosci, 31:1511-34.

Sensorimotor Integration & Prediction Error Learning

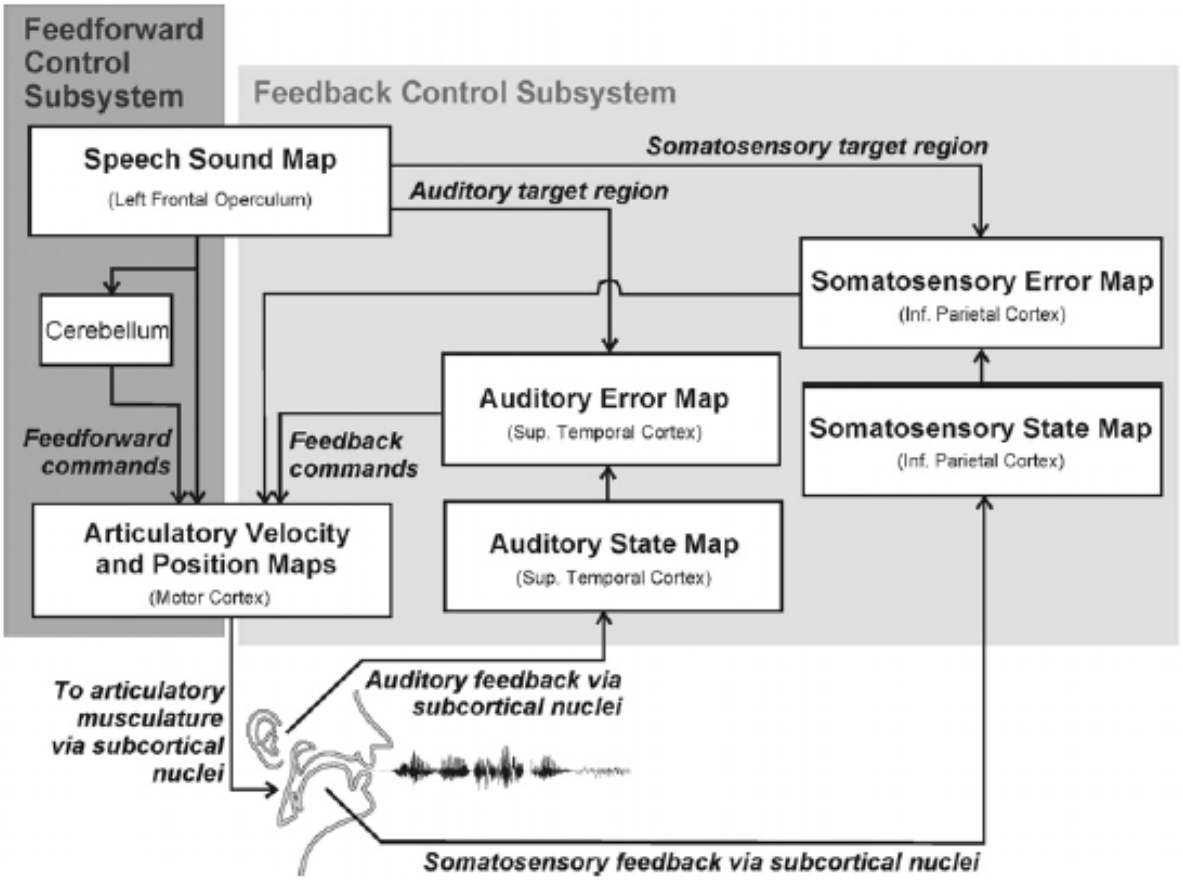
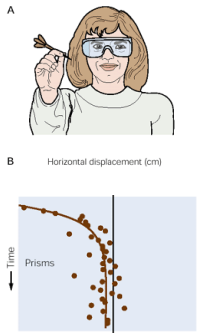
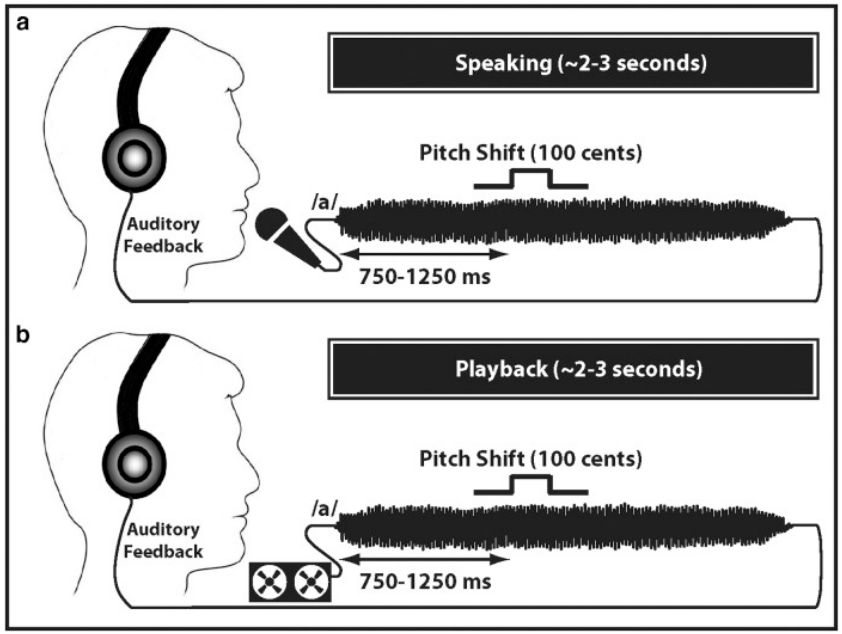


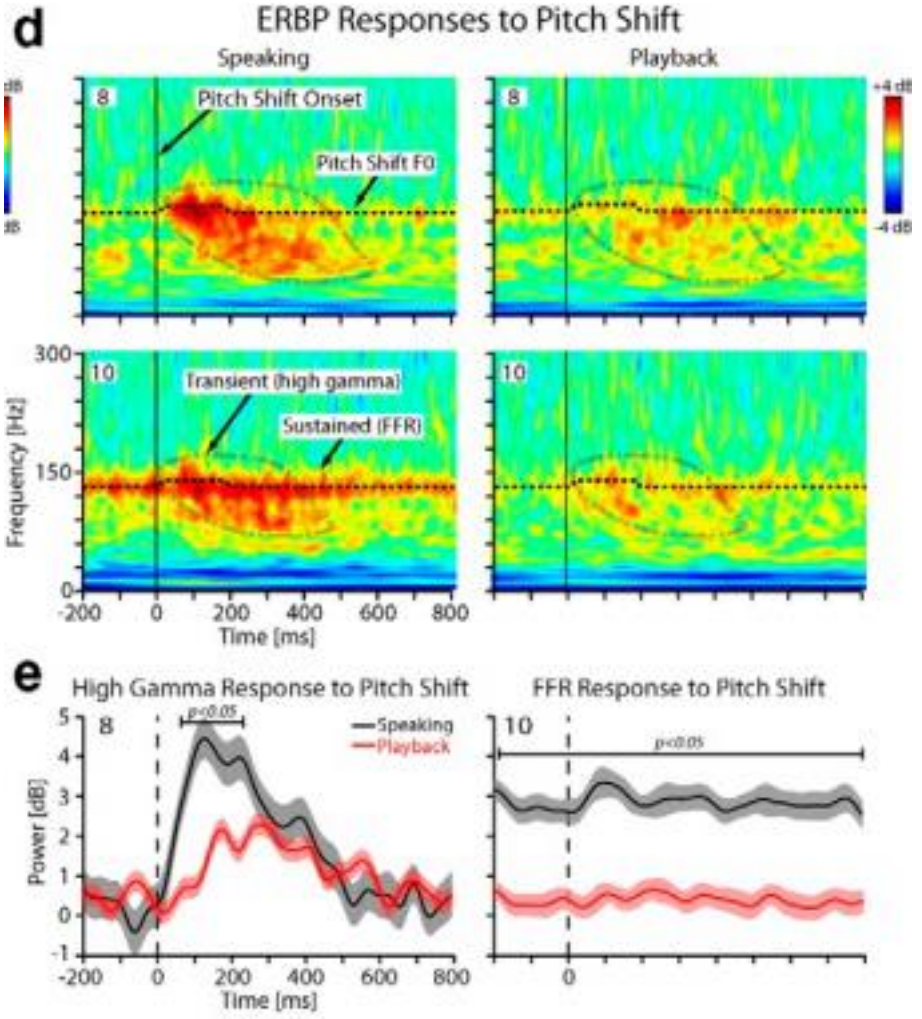
Fig. 1. Schematic of the DIVA model of speech acquisition and production. Projections to and from the cerebellum are simplified for clarity.



Guenther, Journal of Communication Disorders, 2006.

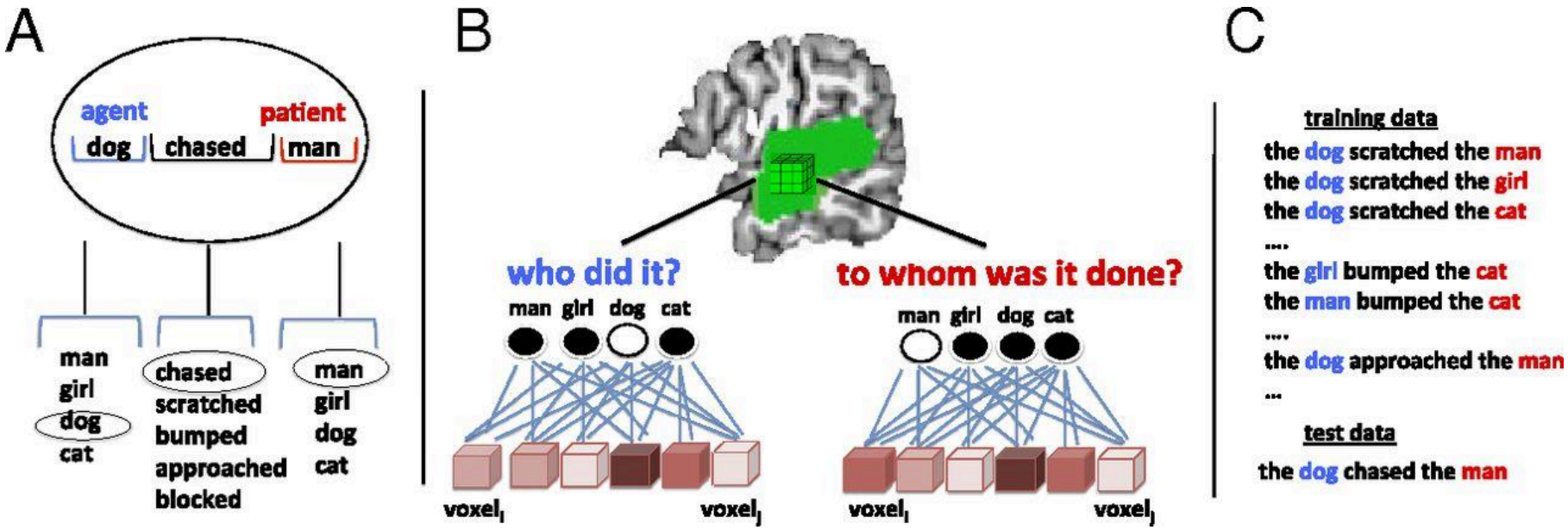
Neurophysiological Support





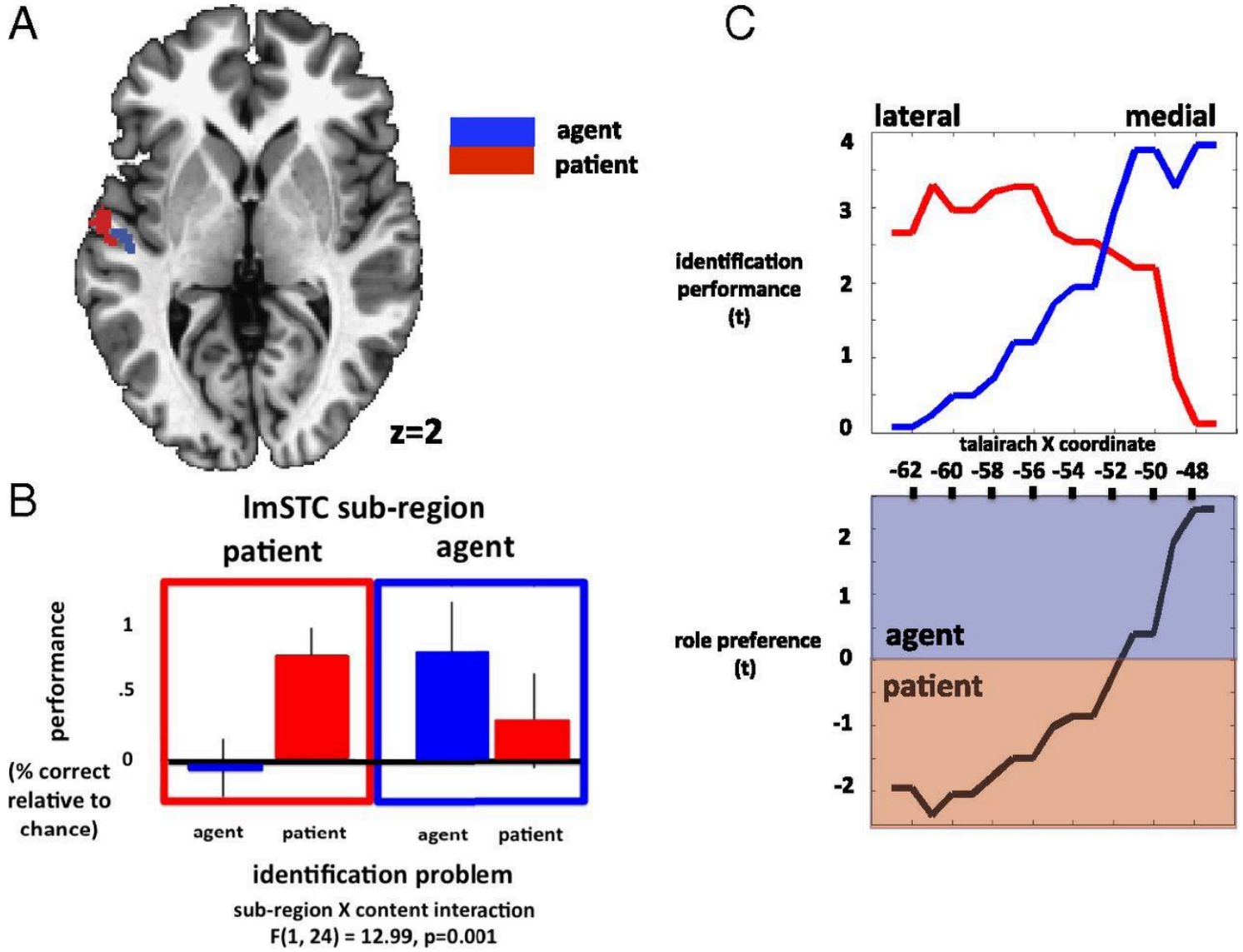
Behroozmand et al. (2016). J Neuroscience 36:2302-15.

Sentence Comprehension



Frankland & Greene (2015). PNAS 112:11732-11737.

Sentence Comprehension



Frankland & Greene (2015). PNAS 112:11732-11737.

Thinking Beyond Language

- Neuropsychology

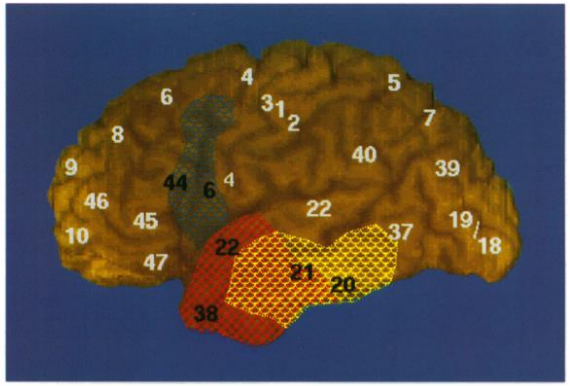


FIG. 1. The image shows superimposed plotting of the lateral extent of the left-hemisphere lesions in the three subjects (red, Boswell; yellow, AN-1033; and blue, KJ-1360). The lesions were plotted on a normal human brain reconstructed in three dimensions by BRAINVOX (6). Numbers represent cytoarchitectonic areas according to Brodmann nomenclature. (*i*) Boswell has bilateral lesions that include the mesial temporal region (amygdala, entorhinal cortex, hippocampus), the lateral temporal cortices (polar region, anterior segment of the first, second, and third and all of the fourth and fifth temporal gyri), the basal forebrain and anterior cingulate, and the internal capsule. The left premotor and prefrontal cortices are intact. (*ii*) AN-1033 has a left anterior temporal lesion that contains mesial and lateral regions. The lateral lesion involves most of the second and third temporal gyri and the anterior segment of the fourth temporal gyrus. The left premotor and prefrontal cortices are intact. (*iii*) KJ-1360 has a left premotor lesion in the posterior segment of the inferior frontal gyrus and the anterior segment of the precentral gyrus. The temporal lobe is intact.

Table 1. Noun and verb retrieval

	Proper nouns, %	Common nouns, %			Verbs, %
		A	F/V	T/U	
Boswell	*4*	*24*	*25*	*76*	92
AN-1033	*8*	*51*	*54*	*70*	96
KJ-1360	78	91	88	95	*53*
Controls					
Mean score ± SD	89 ± 6.2	92 ± 4.3	92 ± 5.4	94 ± 3.8	95 ± 2.8
n	(61)	(97)	(58)	(58)	(210)

Scores are percent correct; values in italics indicate defective retrieval. A, animals; F/V, fruits/vegetables; T/U, tools/utensils.

Damasio & Tranel (1993). PNAS, 90:4957-60.

- Neuroimaging

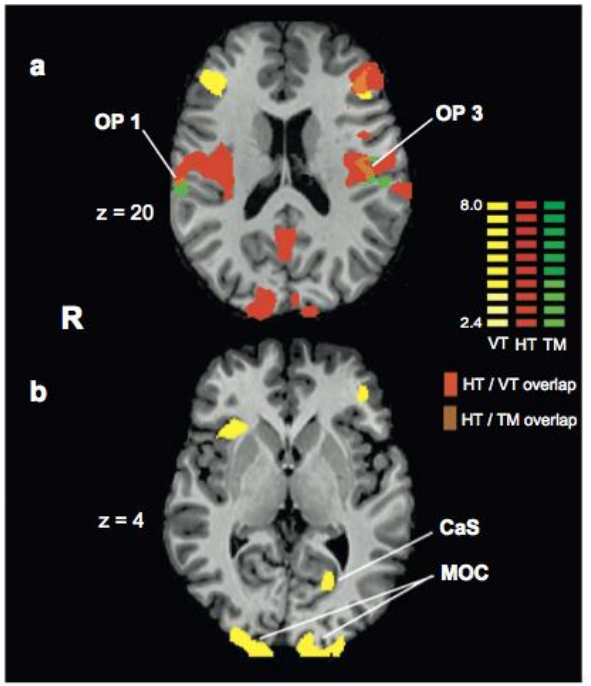
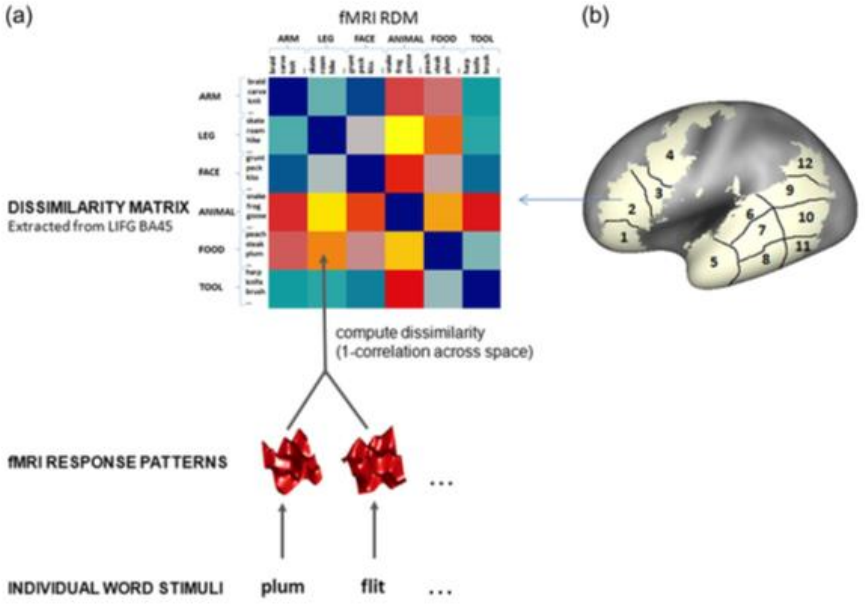
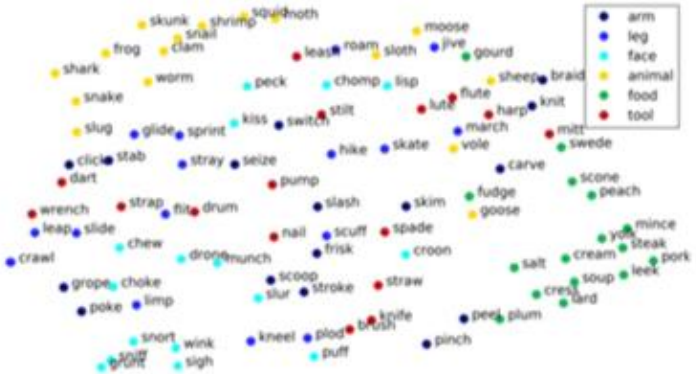


Fig. 1. Textural metaphor and texture perception activations. Axial slices showing (a) textural metaphor activations (green) overlaid on the same individuals' haptic (red) and visual (yellow) texture-selective regions. Overlap zones between these activations (brown) are seen only in the parietal operculum (right OP1 and left OP3 are shown; the overlap in left OP1 was on a more superior axial slice that is not illustrated). Textural metaphor activations do not overlap with other haptic, visual, or multisensory (orange) texture-selective regions in either frontal cortex (bilateral inferior frontal sulcus and gyrus) or (b) visual cortex (MOC: medial occipital cortex; CaS: calcarine sulcus). VT: visual texture; HT: haptic texture; TM: textural metaphor. Talairach z plane shown for each slice; color scale: *t*-scales for the contrasts.

Lacey, Stilla, Sathian (2011). Brain & Lang, 120:416-421.

Further Convergence





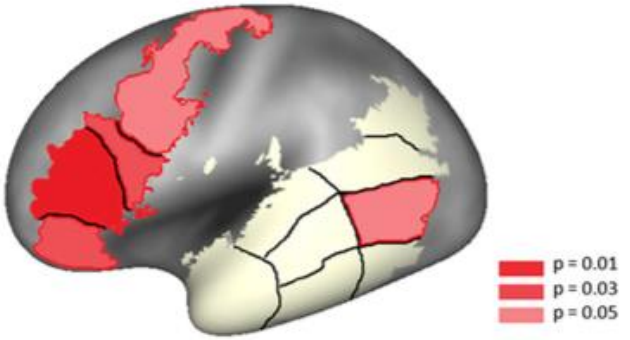


Figure 6. Summary of the multivariate RSA results calculated across all word categories. Regions in which significant correlations were found between categorical structures of fMRI patterns and of the LSA model are shown in red.

Lacey, Stilla, Sathian (2011). Brain & Lang, 120:416-421.

How Far Does it Go?

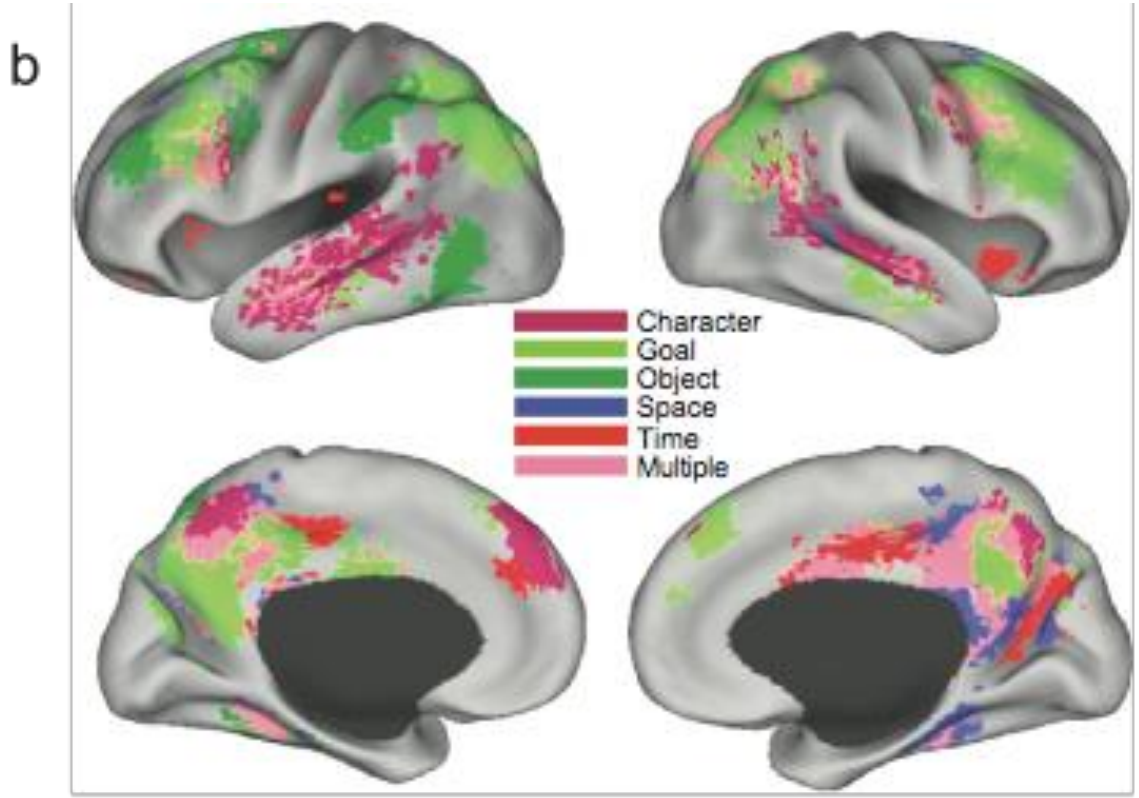


Fig. 1. Coding of a sample passage from the "Waking Up" narrative (a) and brain maps illustrating the location of regions involved in comprehending changes in the narrated situation (b). Each clause was coded for the presence or absence of causal change, character change, goal change, object change, spatial change, and temporal reference (see the text for details). The color coding in (b) indicates which brain regions increased in activity in response to each type of situation change (or two or more types). The top images give inflated left and right lateral views of cortex, and the bottom images give the corresponding inflated medial views.

Speer et al. (2009). Psych Sci, 20:989-99.

Main Points

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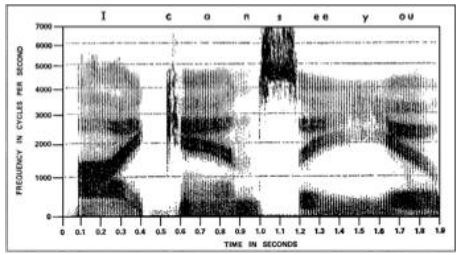
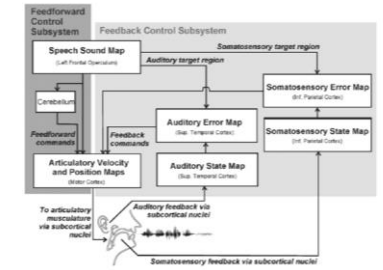
- Speech production
  - Interactive, distributed, hierarchical
- Sensorimotor integration
  - adaptive plasticity & reactivation
- Meaning
  - words, concepts, & perceptual experience





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