

LANGUAGE-RELATED CORTEX SHOWS THREE PHYSIOLOGICALLY AND FUNCTIONALLY DISTINCT WAVES FROM VISUAL TO MOTOR AREAS

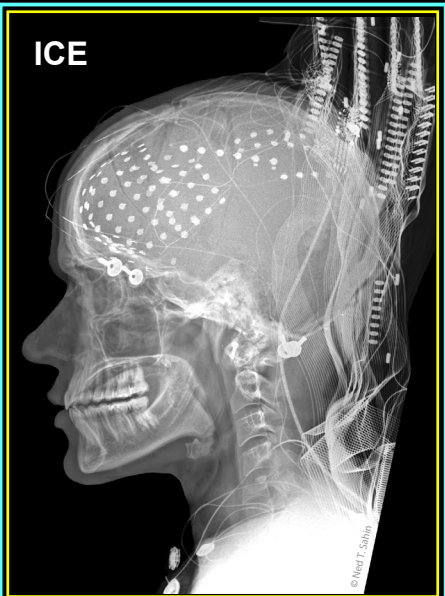


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Intra-Cranial Electrophysiology (ICE)



ICE

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Please visit our new web site (just launching!) a place for the ICE community to share and unite

Theoretical Background

- 1.) Language is crucial and complex, and engages much of the cortex.
- 2.) No end-to-end model (input-cognition-output) exists, esp. not in time + space.
- 3.) Mechanistic understanding is needed for therapy (e.g. stroke); and BCI.
- 4.) The Limiting Factor: For detailed model we need direct neural recordings. Generally this is only possible in animals - and animals don't speak.
- 5.) ICE solves the riddle! High spatial, temporal, physiological resolution.
- 6.) Beyond simple ICE (ERPs), need spectral info: (a) fMRI correlates with different bands, (b) high-gamma ~ cell firing, while ERP = low-band.
- 7.) Goal: chart progression and dynamics of neuronal activity for language across the entire cortex, in various frequency bands.
- 8.) *A priori*, we predict a progression: ~V1 -> VWFA -> Wernicke's -> Broca's. But, scarce existing literature: need mix of *a priori* and exploratory study.

Cognitive Task

(Subject mentally produces correct form of word here.)

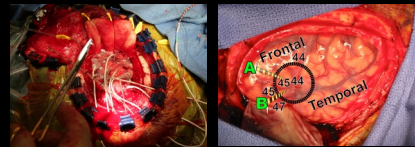


Inflectional Condition	Context Frame	Example Word	Response (mental)
Read	repeat word ____	to walk	walk
Null-Inflect	Every day they ____	to walk	walk
Overt-Inflect	Yesterday they ____	to walk	walked

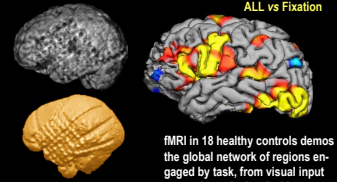
Conditions	fMRI Contrasts	iERP Search Patterns
Read	R	$(O \approx N) > R$ Biased toward Grammatical Processing
Null-Inflect	N	$O > (N \approx R)$ Biased toward Articulatory Planning and Output
Overt-Inflect	O	

Results

Electrode Locations

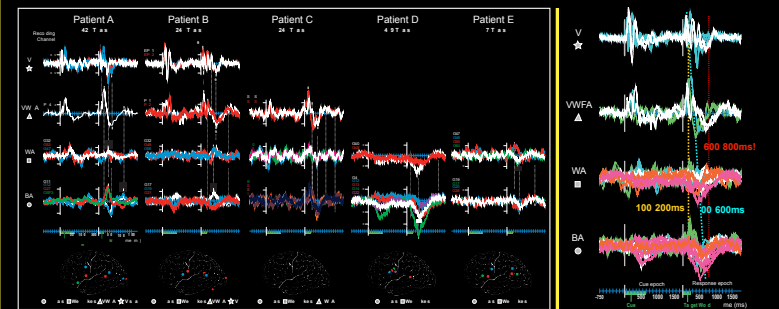


Implantation of electrodes during epilepsy surgery. Goal is (a) to locate the epilepsy-causing tissue deep in the brain (removing it cures the epilepsy), and (b) to map all the healthy functions in the cortex (removing them must be avoided). Meanwhile we obtained direct neural recordings for our task from healthy language-related cortex.



fMRI in 18 healthy controls demos the global network of regions engaged by task, from visual input areas, through classical language areas, to motor output areas.

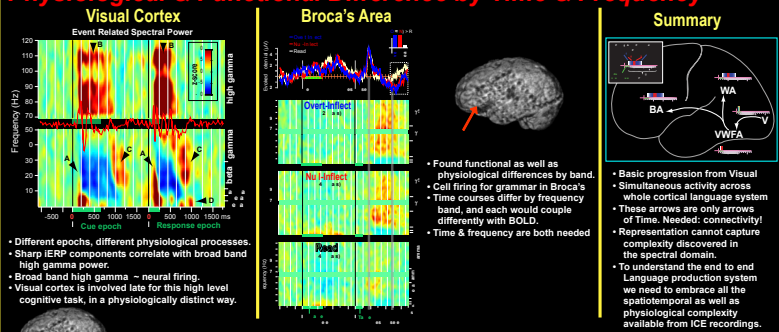
Subdural Evoked Potentials, Across Patients and Regions



Evoked cortical potentials from subdural electrodes reveal complex dynamics across major functional regions, consistently across patients: early and late waves bracket the predicted progression.

Summary of EPs: 3 distinct waves

Physiological & Functional Difference by Time & Frequency



Summary & Conclusions

- 1.) Our task engages end-to-end system: fMRI revealed known cortical regions for Input-Cognition-Output.
- 2.) For first time, ICE revealed the predicted progression of activity: ~V1->VWFA->Wernicke's->Broca's.
- 3.) Unexpected dynamics: (a) Early wave: quick progress from Visual to Broca's, (b) Late wave: peri-utterance wave of activity includes "early" visual areas (surprisingly, 500ms after visual stimulus is extinguished).
- 4.) Wavelet analysis revealed PHYSIOLOGICALLY different epochs (e.g. early vs late activity in visual cortex).
- 5.) Further analysis revealed FUNCTIONALLY different epochs as well as spectral bands (e.g. in Broca's area).
- 6.) Spatial, temporal, and physiological resolution of ICE is necessary to understand the language system.
- 7.) Tentative: Late wave of activity = network's solution to "binding problem" (re-assembling channels of info)?
- 8.) Further research: (a) Chart further differences/patterns by time & frequency, (b) Connectivity analysis.

REFERENCE: SAHIN, PINKER, CASH, SCHOMER, HALGREN, *SCIENCE*, 326, 445-449 (2009)

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