Neural networks supporting auditory-visual speech:
Evidence from invasive neural recordings in humans

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INTRODUCTION

Late integration models posit that modality specific stimuli are processed in a domain-specific manner in their respective brain regions before their information is passed along and integrated in AV areas.[1,2]

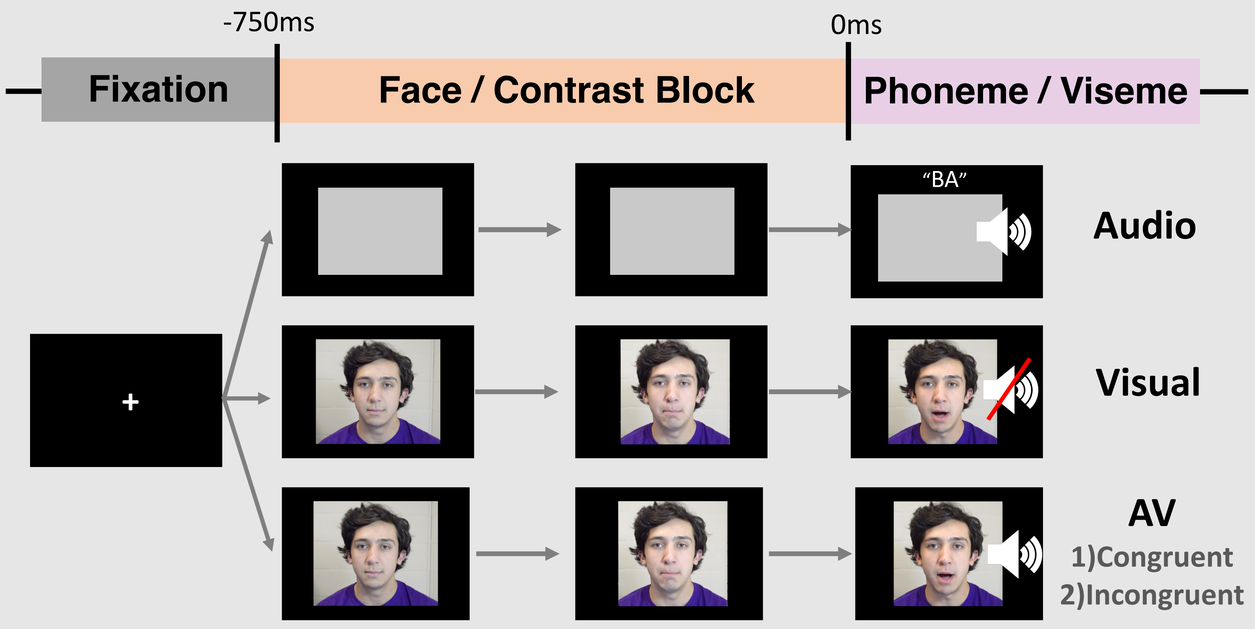
Early integration models, in contrast, suggest that auditory-visual integration occurs in parallel with modality specific processes.

Unlike fMRI, electrocorticographic (ECoG) recordings provide high spatial and temporal resolution well-suited for testing such models.[3]

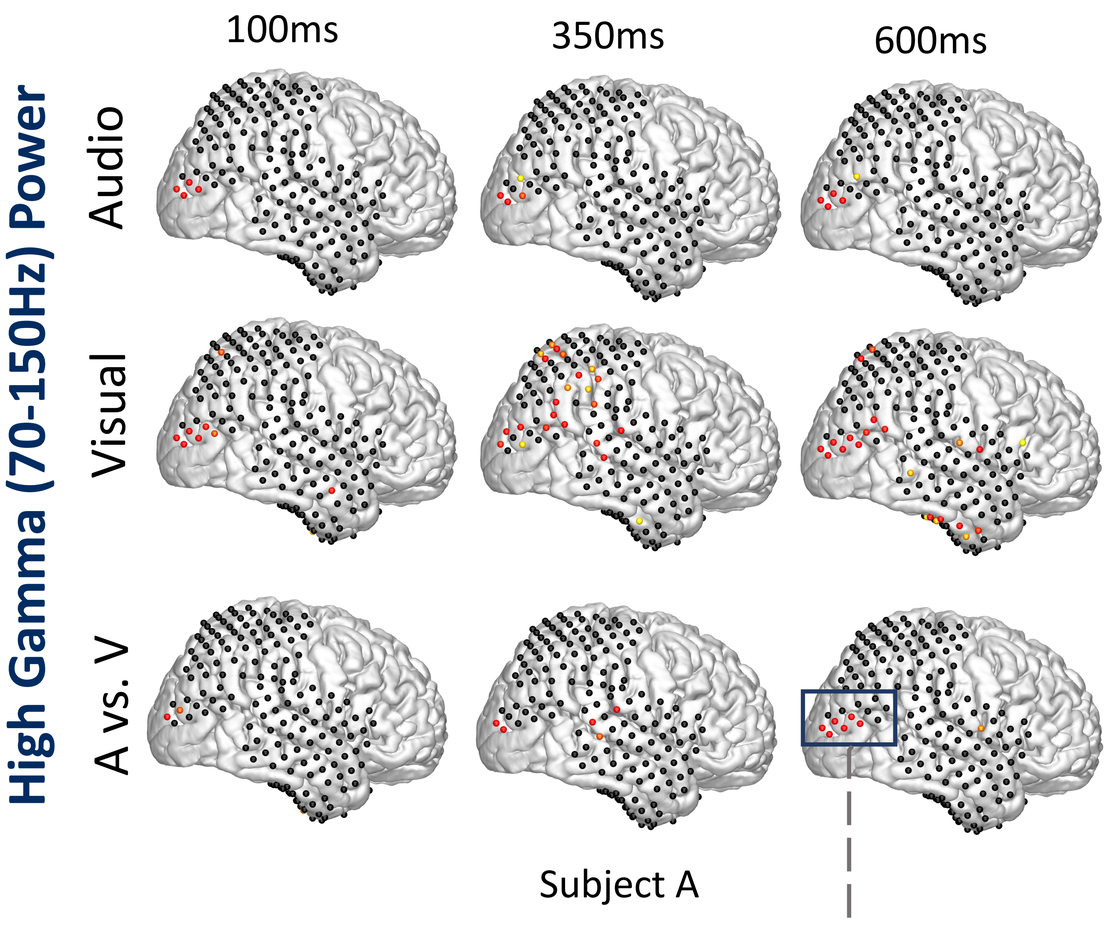
Using ECoG, we looked for evidence that would provide insight into the distribution and timing of auditory-visual speech integration.

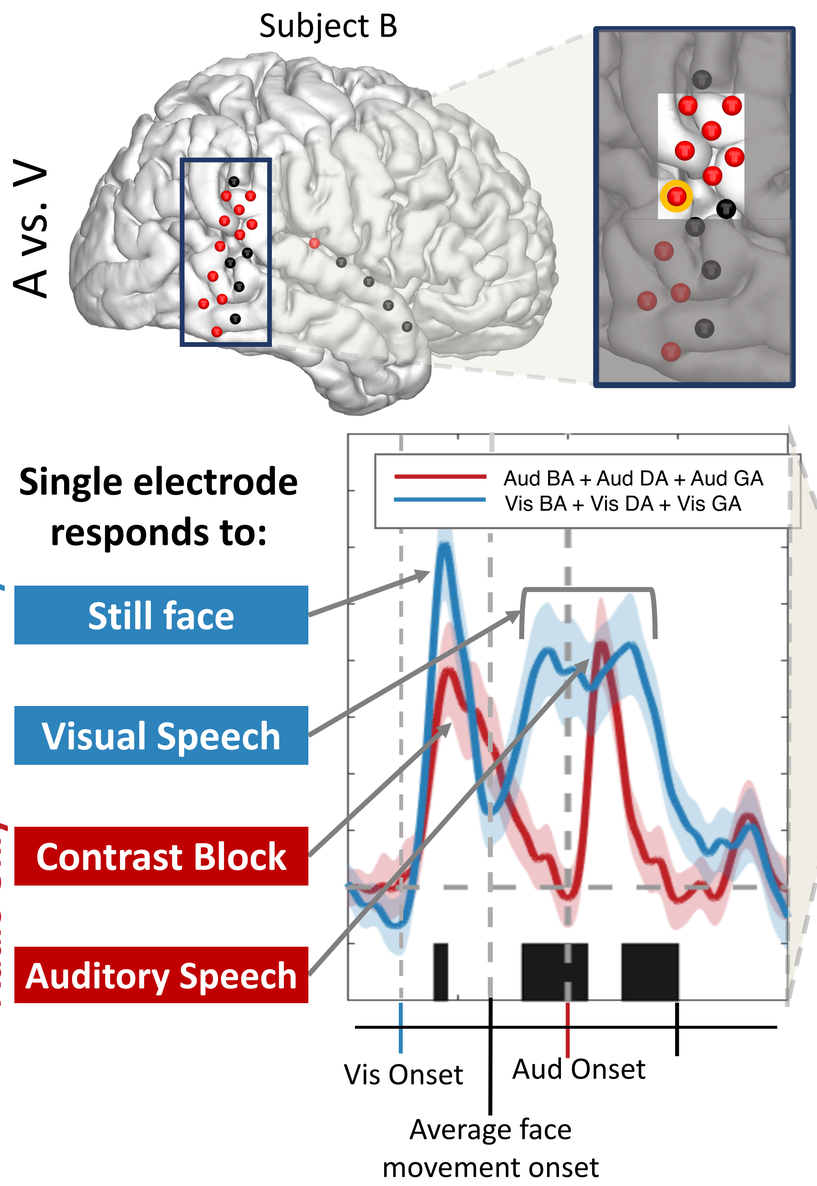
METHODS

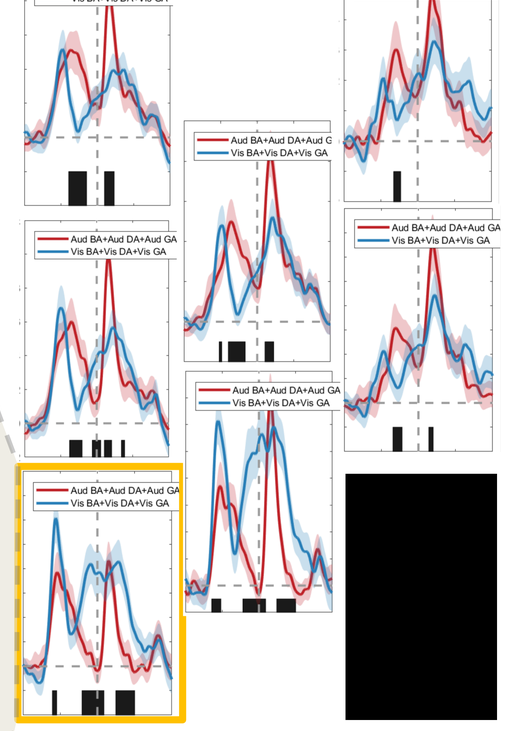
Intractable epilepsy electrocorticography (ECoG) patients



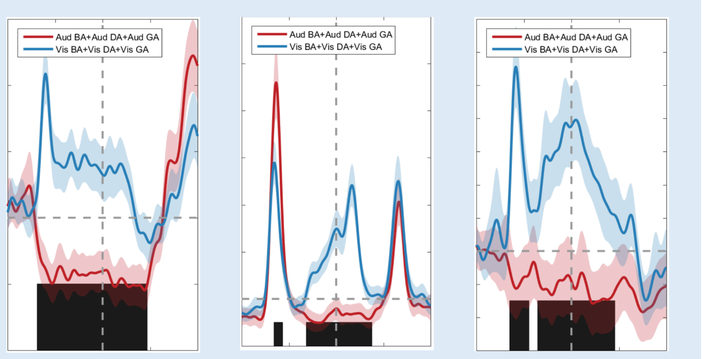
AFTER FACE / CONTRAST BLOCK (BEFORE PHONEME ONSET)



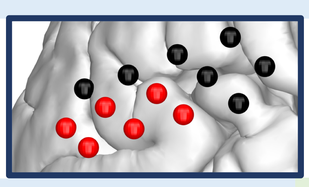


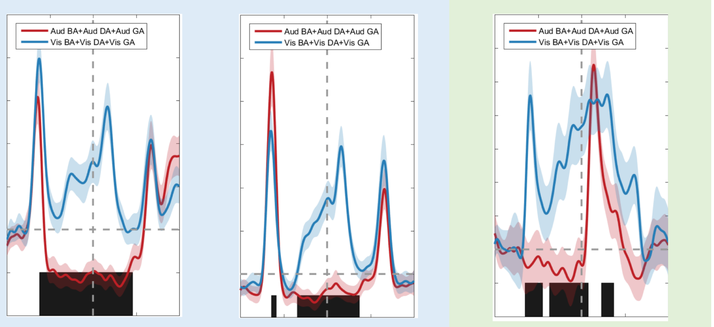


- This "multisensory" electrode in pSTS region is activated by the initial presentation of both visual and auditory stimuli (separately), suggesting non-modality specific processing of unisensory stimuli



Visual Only
Audio Only





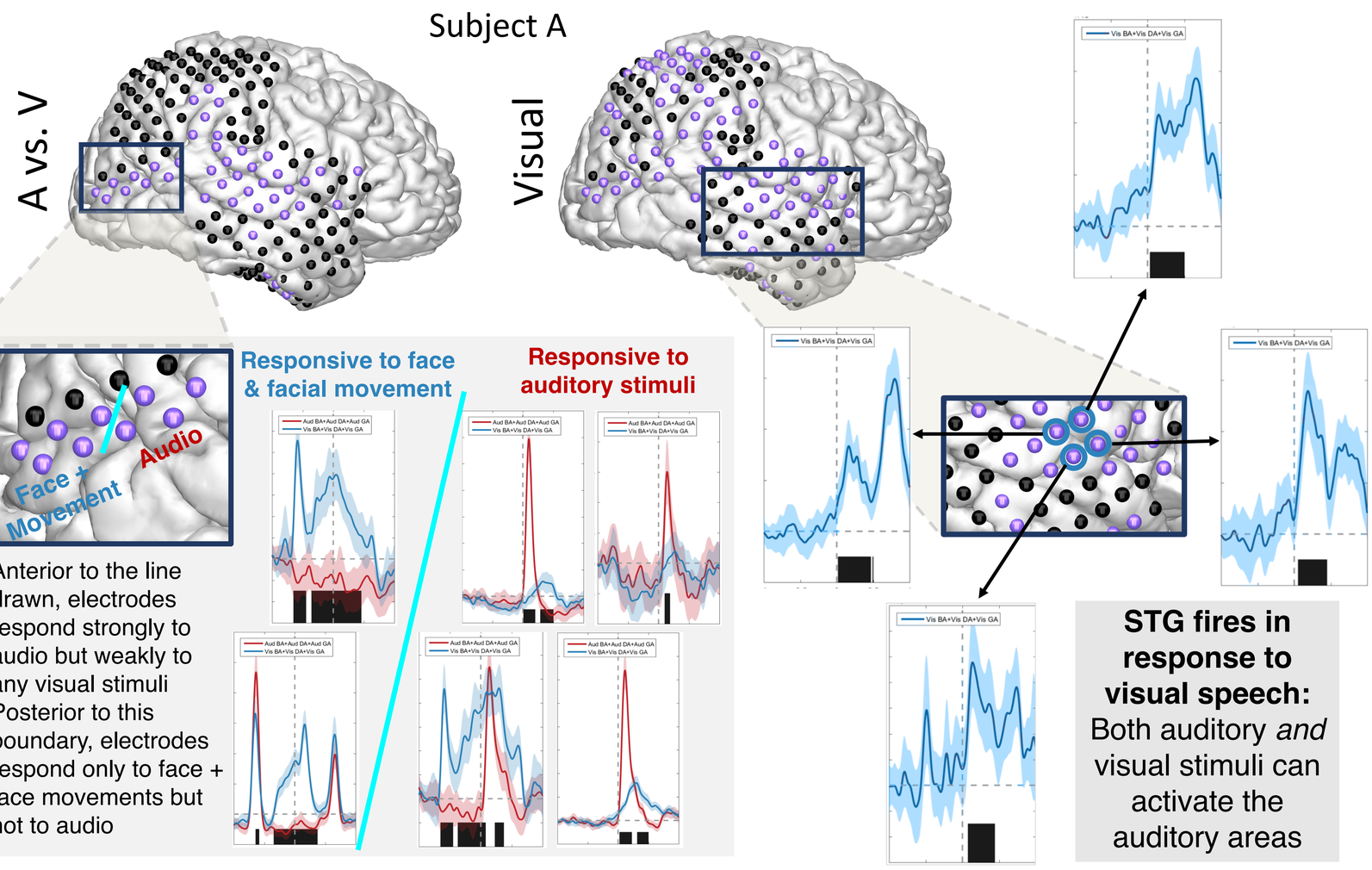
Different patterns of activity for contrast block vs. face (+ movements)

- Sustained activity for faces + face movement
- Responds to onset and offset of contrast block

"Multisensory" Electrode

- Activated by face + face movement
- Activated by audio

AFTER PHONEME / VISEME



- Anterior to the line drawn, electrodes respond strongly to audio but weakly to any visual stimuli
- Posterior to this boundary, electrodes respond only to face + face movements but not to audio

STG fires in response to visual speech:
Both auditory *and* visual stimuli can activate the auditory areas

DISCUSSION

Data suggest:

1.) AV processing occurs in parallel with the initial processing of the stimuli

2.) Distinct audio and visual information processing is not restricted to their respective modality specific brain areas.[4,5]

3.) There is a functional boundary near/in pSTS (which in previous literature has shown a distinction between noisy vs. clean AV speech[6]) to audio-alone vs. visual-alone speech.

⬇

AV processing and integration likely occurs in a parallel, non-serial manner much earlier in the processing hierarchy than is suggested by the late integration model.

REFERENCES

1. Grant KW, Walden BE, Seitz PF. Auditory-visual speech recognition by hearing-impaired subjects: Consonant recognition, sentence recognition, and auditory-visual integration. Journal of the Acoustical Society of America. 1998;103:2677–2690.
2. Peelle, J. E., & Sommers, M. S. (2015). Prediction and constraint in audiovisual speech perception. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *68*, 169–181.
3. Parvizi, J., & Kastner, S. (2018). Promises and limitations of human intracranial electroencephalography. *Nature neuroscience*, 1.
4. Zweig, L. J., Grabowecky, M., Suzuki, S., Towle, V., Tao, J., Wu, S., & Brang, D. (2016). Silent lip reading generates speech signals in auditory cortex. *Journal of Vision*, *16*(12), 463-463.
5. Brang, D., Towle, V. L., Suzuki, S., Hillyard, S. A., Di Tusa, S., Dai, Z., ... & Grabowecky, M. (2015). Peripheral sounds rapidly activate visual cortex: evidence from electrocorticography. *Journal of neurophysiology*, *114*(5), 3023-3028.
6. Ozker, M., Yoshor, D., & Beauchamp, M. S. (2018). Converging Evidence From Electrocorticography and BOLD fMRI for a Sharp Functional Boundary in Superior Temporal Gyrus Related to Multisensory Speech Processing. *Frontiers in human neuroscience*, *12*.

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