Anticipation of temporally structured events in the brain

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Introduction

- The brain contains a hierarchy of information integration over long timescales (Aly, Chen, Turk-Browne, & Hasson, 2018; Hasson, Chen, & Honey, 2015), with lower-order areas (e.g., visual cortex) primarily representing the current moment, and higher-order areas (e.g., mPFC) integrating information over many seconds or minutes in the past (Baldassano et al., 2017, 2018).

- We examine whether this hierarchy can be used to predict upcoming information in familiar narrative sequences, and how that prediction is represented.

- **Hypothesis: The brain generates predictions along an anterior-posterior hierarchy, with higher-order regions predicting further in the future than lower-order regions.**

Data

We reanalyzed fMRI data from Aly et al., 2018

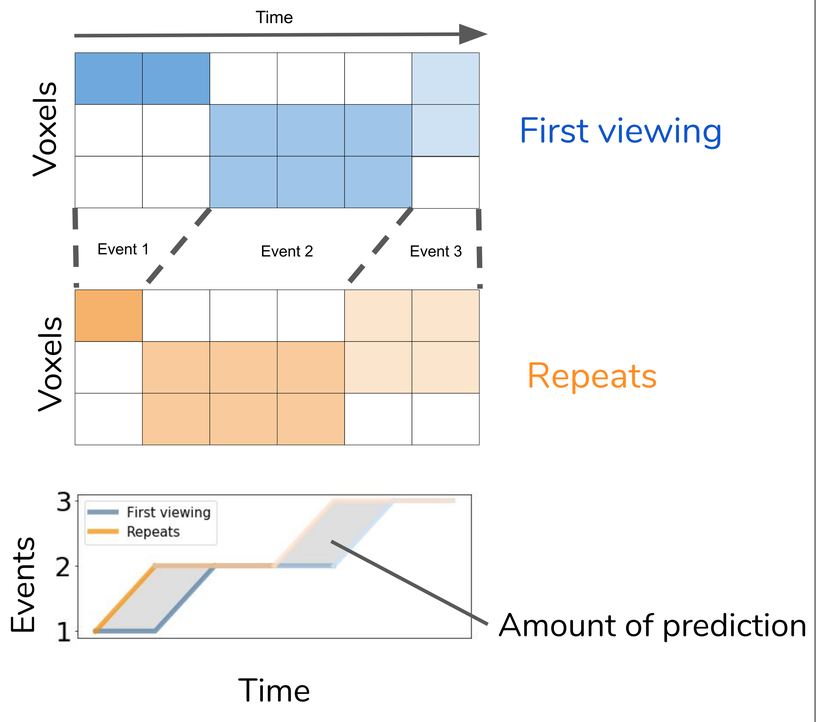
- 30 individuals watched a 90-second clip from the movie *The Grand Budapest Hotel*, **six times**.
- TR = 1.5s; voxels (2mm x 2mm x 2mm); whole-brain

References

1. Aly, M., Chen, J., Turk-Browne, N. B., & Hasson, U. (2018). Learning Naturalistic Temporal Structure in the Posterior Medial Network. *Journal of Cognitive Neuroscience*, 30(9), 1345–1365. https://doi.org/10.1162/jocn_a_01308
2. Baldassano, C., Chen, J., Zadbood, A., Pillow, J. W., Hasson, U., & Norman, K. A. (2017). Discovering Event Structure in Continuous Narrative Perception and Memory. *Neuron*, 95(3), 709-721.e5. https://doi.org/10.1016/j.neuron.2017.06.041
3. Baldassano, C., Hasson, U., & Norman, K. A. (2018). Representation of Real-World Event Schemas during Narrative Perception. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, 38(45), 9689–9699. https://doi.org/10.1523/JNEUROSCI.0251-18.2018
4. Hasson, U., Chen, J., & Honey, C. J. (2015). Hierarchical process memory: memory as an integral component of information processing. *Trends in Cognitive Sciences*, 19(6), 304–313. https://doi.org/10.1016/j.tics.2015.04.006

Analysis

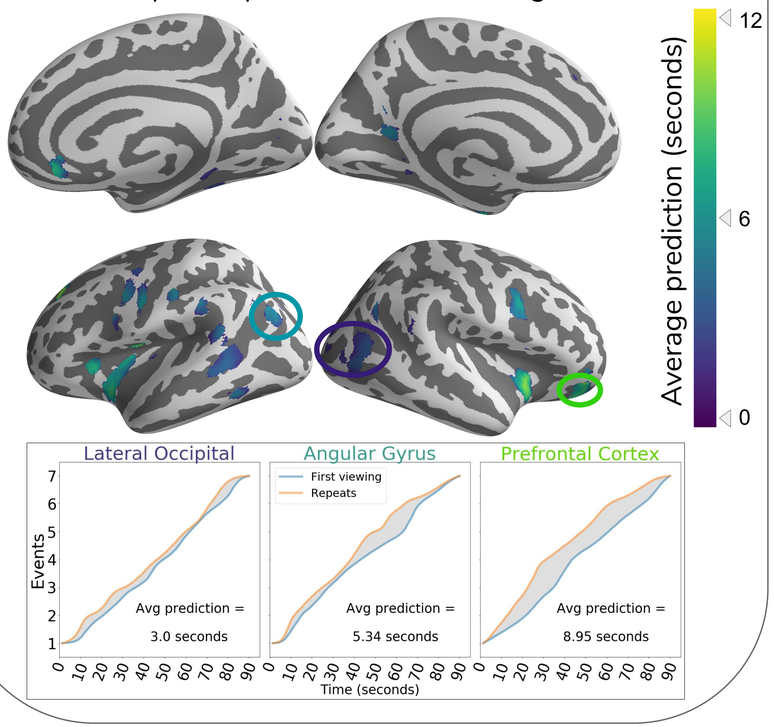
- Goal: detect whether voxel response timecourses (corresponding to event boundaries) are shifted earlier in time on repeated viewing.
  - Timescale of prediction may vary across regions
  - Amount of prediction may vary throughout the clip
- We used a Hidden Markov Model fit over group-averaged time series data to a sequence of multivoxel patterns that appeared during both initial viewing and later viewings, but that may be temporally shifted.



- Whole-brain results were obtained using a searchlight analysis (radius = 5 voxels)
- Statistical thresholding was conducted via bootstrapping, with correction for False Discovery Rate (q<0.05)

Results

- Searchlight analysis revealed temporal shifts in event patterns up to 12 seconds ahead on subsequent compared to first viewing.
- Degree of anticipation varied along a temporal hierarchy, from posterior to anterior regions.



Discussion

- Multiple brain regions exhibit flexible predictions of upcoming audiovisual narrative stimuli.
- Prediction occurs at varying timescales: higher-order regions predict further in the future than lower-order regions.
- Future experiments will determine whether prediction requires schema-consistent knowledge; analyses will explore alignment of event boundaries and stimuli.