Towards holistic neural encoding models for multi-modal naturalistic stimuli

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INTRODUCTION

- Neural encoding models predict cortical responses to novel stimuli. They:
  - Can shed light on functional organization
  - Can generate testable hypothesis
  - Are not paradigm bound
- There is dearth of machine learning models that exploit multi-sensory information to predict evoked neural response
- We propose an end-to-end deep neural network based encoding model that uses audio and visual stimuli sequences jointly to predict cortical responses.

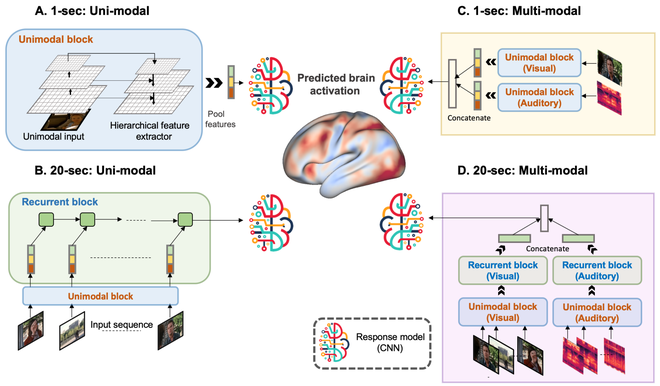
OBJECTIVES

GOAL: Build predictive models of cortical responses to arbitrary complex, dynamic stimuli

Our proposed model captures three critical inductive biases about information processing in the brain:

- *Hierarchical processing*
- *Influence of temporal history*
- *Multi-sensory assimilation*

MATERIALS & METHODS



MODEL INPUTS

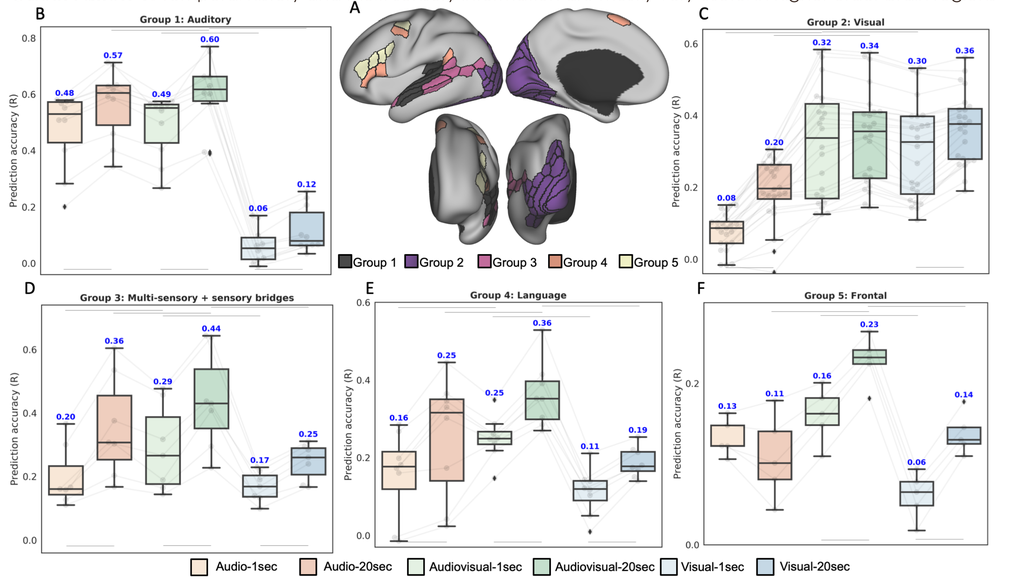
1. Audio-1sec: 1sec spectrogram
2. Visual-1sec: Single RGB frame, sampled every second
3. Audiovisual-1sec: 1sec spectrogram & 1 RGB frame
4. Audio-20sec: sequence of 20 consecutive spectrograms
5. Visual-20sec: sequence of 20 consecutive RGB frames
6. Audiovisual-20sec: sequences of 20 spectrograms and RGB frames

DATASET:

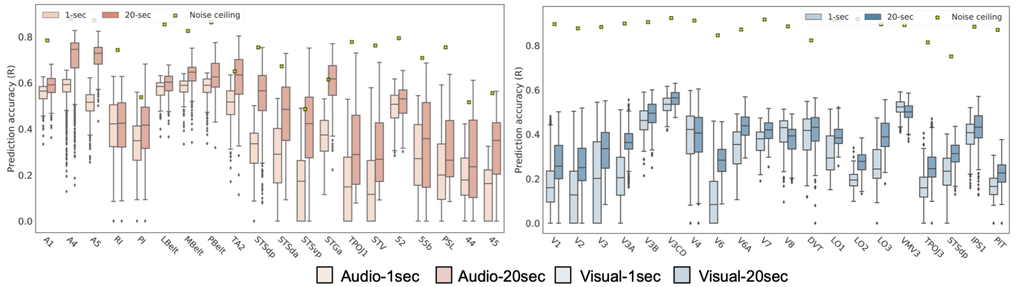
- 7T fMRI measurements from 158 subjects watching 4 audio-visual movies
- *Training/validation set*: 2265 stimulus-response pairs; *Testing set:* 699 stimulus-response pairs

RESULTS

Observation 1: Temporal history and multi-sensory information are mostly very useful in higher order brain regions

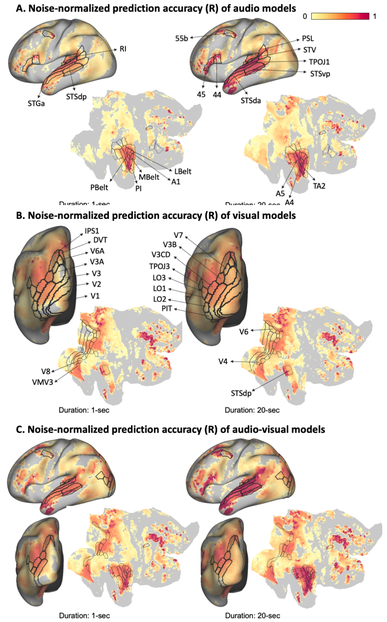


Observation 2: Among dominantly uni-sensory regions, longer time-scales improve performance in higher order auditory regions and dorsal visual stream



RESULTS (contd.)

Observation 3: Auditory and visual features jointly approach noise ceiling in multi-sensory regions



CONCLUSIONS

- Exploiting knowledge about stimulus along the axes of timescales and sensory modality substantially increases prediction accuracy of neural responses
- Encoding models can form an alternate framework to probe the preferred time-scales and sensory modality of different brain regions

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