Formalizing Medial Temporal Lobe involvement in perception: From psychological constructs to function approximation

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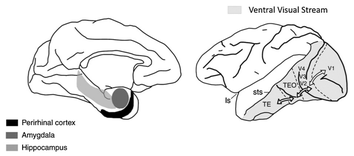
BACKGROUND

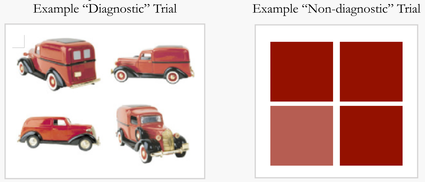
Perirhinal cortex (PRC) is a MTL structure situated at the apex of the primate ventral visual system (VVS)

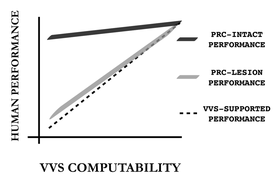


Competing accounts of PRC-related deficits on perceptual tasks:

Mnemonic Account:
PRC-related deficits due to either (i) Damage in adjacent sensory cortex, e.g. inferior temporal (IT) cortex or (ii) Memory-related task demands (Suzuki 2009)

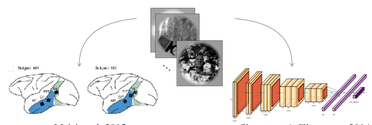
Perceptual-Mnemonic Account:
PRC enables object-level representations not supported by more posterior regions of the VVS (Bussey & Saksida 2002)

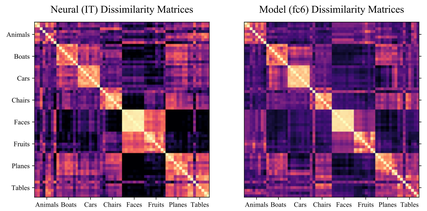




However, reliance on *descriptive properties* of stimuli has made it difficult to evaluate experimental results and generate novel diagnostic stimuli

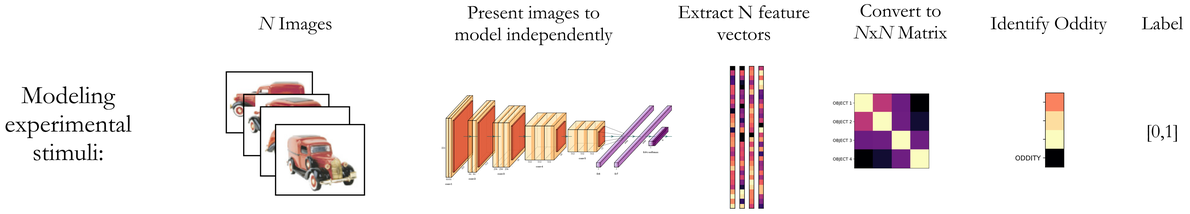
Convolutional Neural Networks predict neural responses throughout the VVS (e.g. V1: Cadena et al. 2019 | V4: Bashivan et al. 2019 | IT: Yamins et al. 2014)





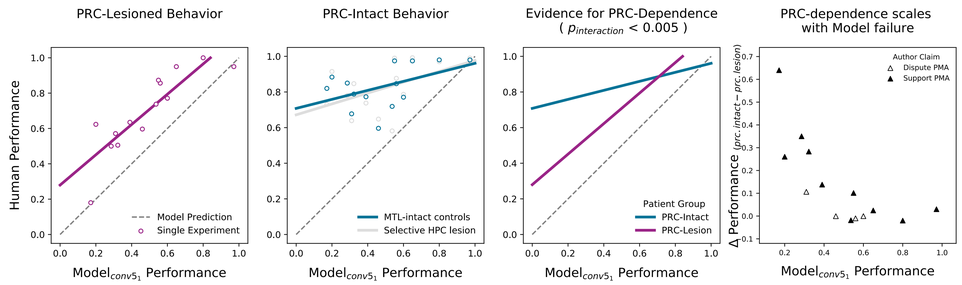
COMPUTATIONAL META-ANALYSIS

(i) Collect published experiments (ii) model stimuli with VVS proxy (iii) relate model-human behavior



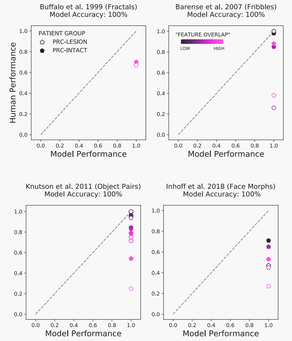
Does this computational proxy for the VVS reflect the behavior of PRC-lesioned subjects?

DIAGNOSTIC



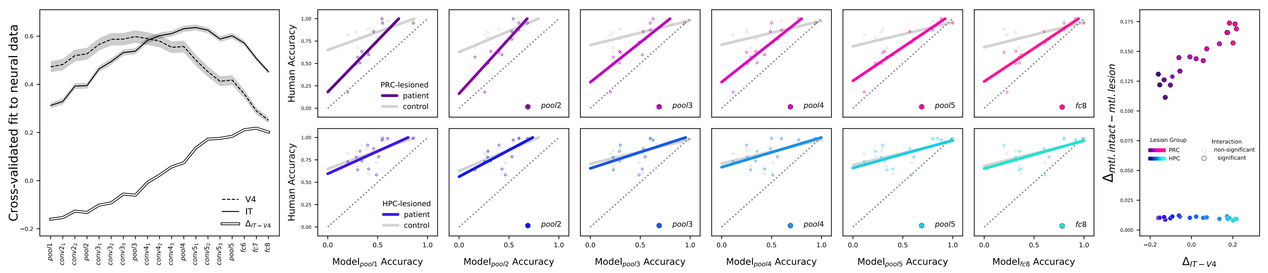
Yes:
- PRC-lesioned behavior is well characterized by a computational proxy of the VVS
- PRC-intact behavior diverges from both VVS-model and PRC-lesioned behavior
- PRC-intact/lesion behavioral divergence across experiments scales with model failure

NON-DIAGNOSTIC



Not all "complex" stimulus sets are diagnostic of perirhinal function

Can we make focal anatomical claims about *where* in the VVS PRC-lesioned behavior is reliant on?



No:
- Differential layer by layer fit to IT correlates with differential fit to PRC-lesioned behavior
- However, this differential fit to PRC-lesioned behavior is significant across all layers
- We could expect similar results regardless where PRC-lesioned behavior was reliant on

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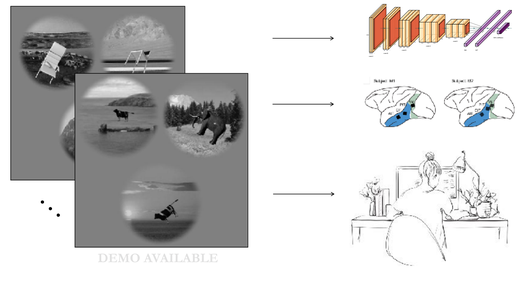
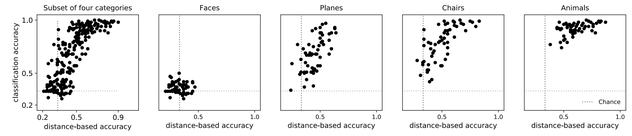
MODEL-BASED EXPERIMENTAL DESIGN

There are many shortcoming with the available analyses. To address some of these, we leverage this modeling approach to generate a novel experiment

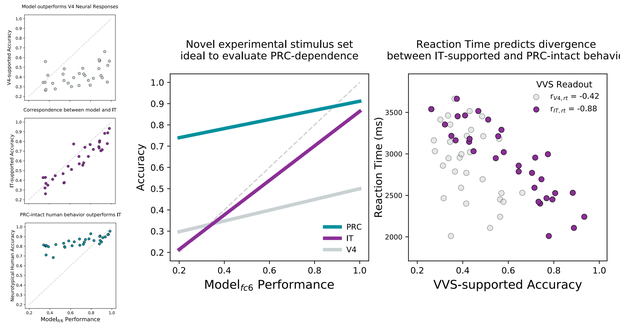
desiderata
- Separable IT/V4 supported behaviors
- Neurotypical subjects > readout of IT
- Parametrically modulate "complexity"
- Experimental duration < 30 minutes



Estimating model and neural performance on 224 oddity tasks: a modified leave-one-one cross-validation strategy



- Human subjects (n = 297) performing 224 oddity tasks online (mturk)
- Behavioral reliability of estimates at multiple resolutions
  - Accuracy: category: .97±.03 | **object: .71±.07** | item: 60±.05
  - Reaction time: category: .99±.01 | **object : 91±.02** | item .62±.05



SUMMARY

- PRC-lesioned behavior is well approximated by computational model of the VVS
- PRC-intact behaviors (MTL-intact & HPC lesions) diverge from model performance
- Results suggest PRC implicated in concurrent visual discrimination ('oddity') tasks
- Available stimuli don't enable claims about VVS-dependence in PRC-lesioned state
- Leveraged model to develop experiment that exhibits ideal stimulus properties
- Neurotypical divergence from IT-supported accuracy covaries with reaction time