

Perceptual decision making is supported by a hierarchical processing cascade in both biological and artificial neural networks

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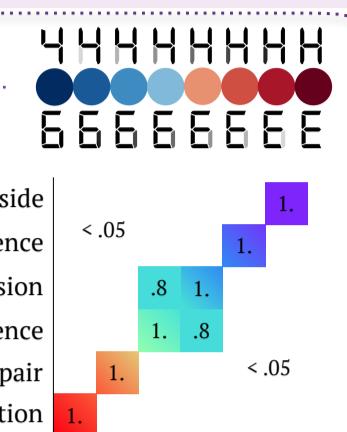
1 Introduction

- Object recognition recruits a **hierarchy** of cortical regions [1] and evokes a rapid feedforward response [2]
- The underlying mechanisms are presently unknown, due to limited **joint spatio-temporal** insight

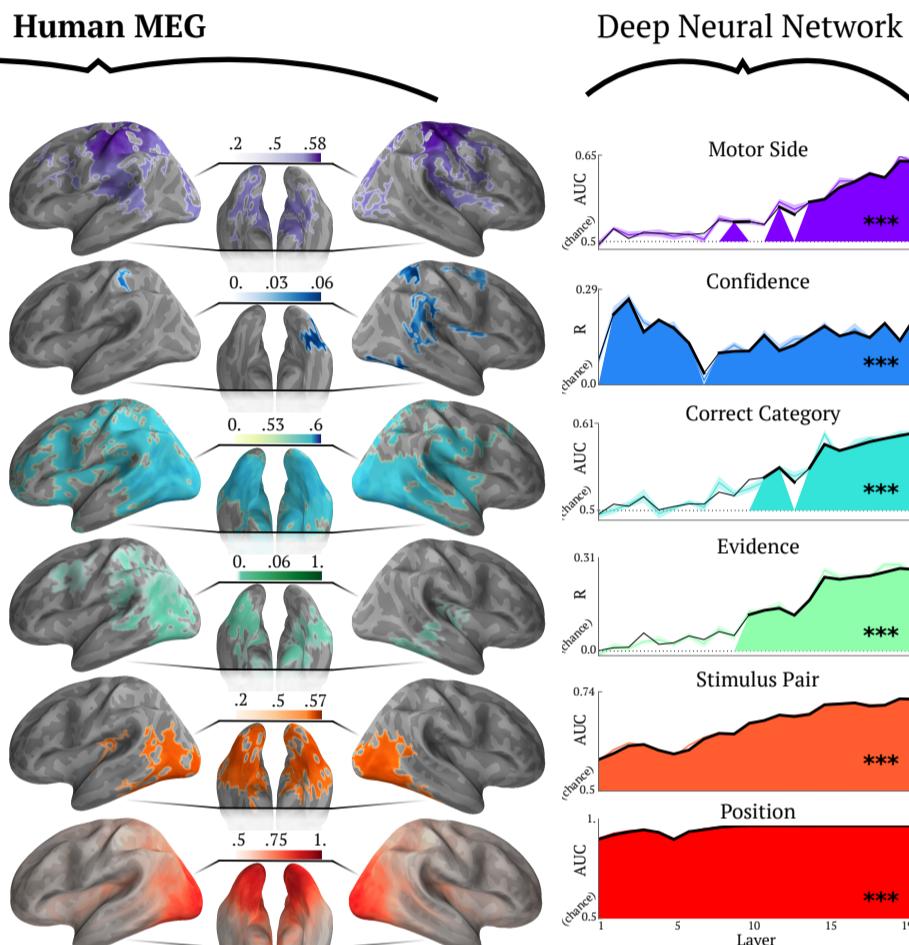
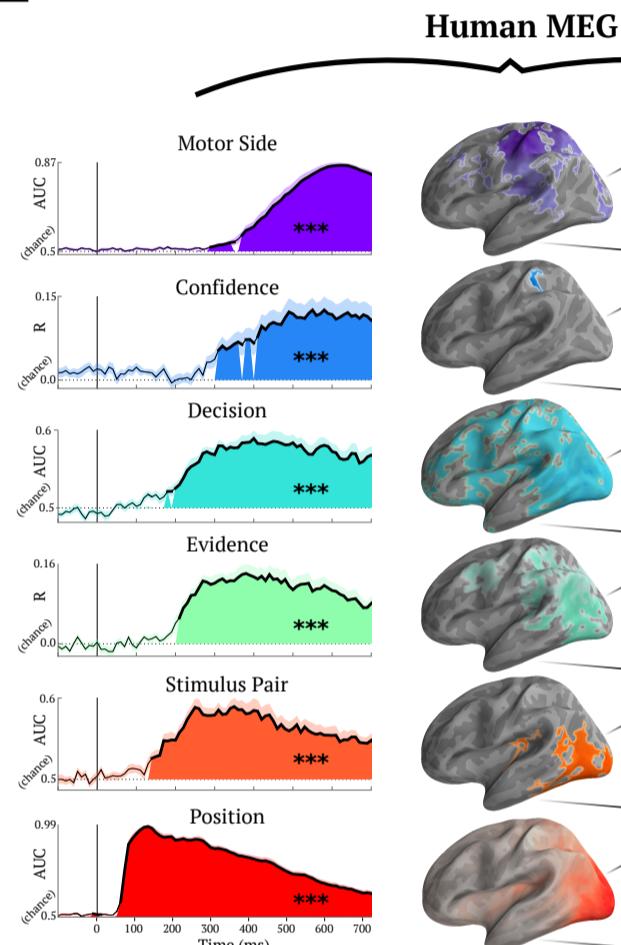
What neural mechanisms transform sensory input into perceptual experience?

2 Method & Analysis

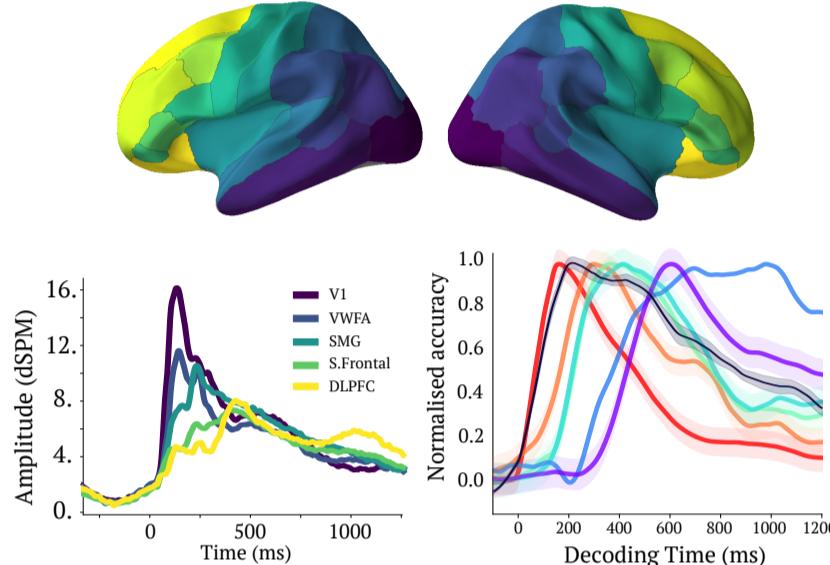
- 17 participants made **letter/digit judgements**
- MEG was recorded with a 306 channel system
- We decoded **six orthogonal features** from whole brain MEG signals over time and space
- The same features were decoded from each layer of a deep neural network (DNN)



3 Hierarchical processing cascade



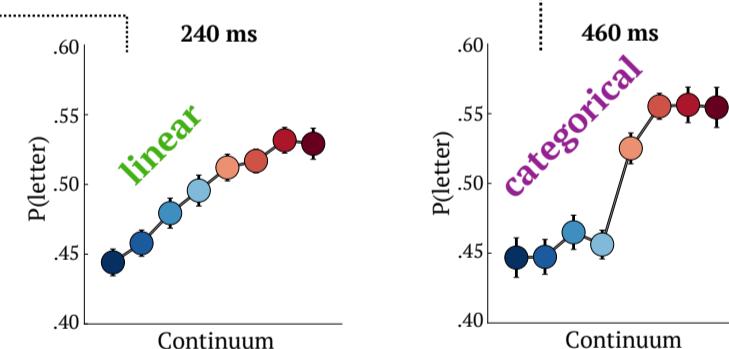
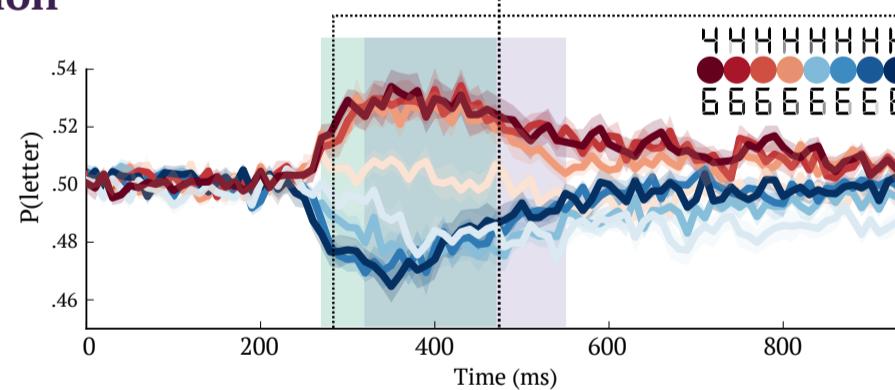
4 Information held in recurrency



- All six features are decodable from the human brain and the DNN
- The brain implements a **hierarchical cascade** architecture (DNN does not*)
- Features are maintained in parallel until the response, and **decodable from recurrent (not initial feedforward) activity**

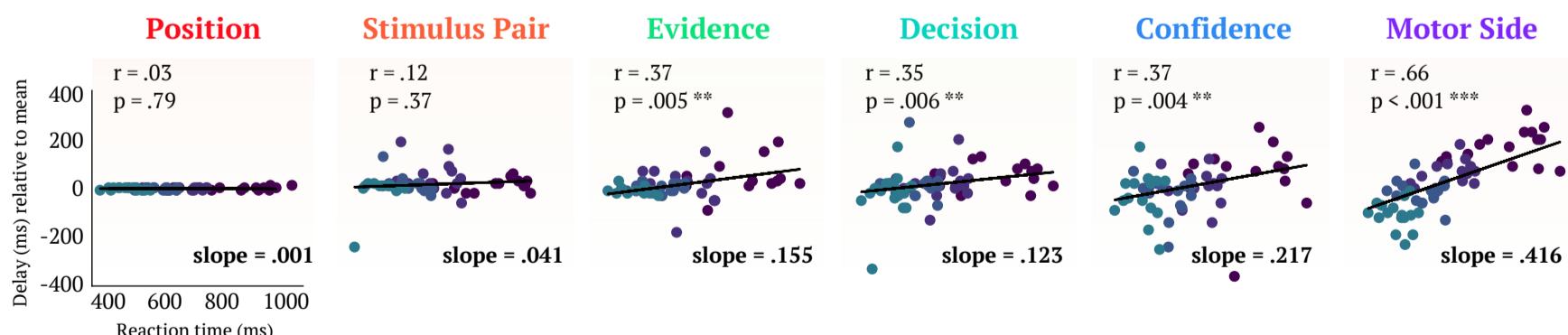
5 Evidence accumulation

- Sensory evidence is **accumulated over time**
- Representation of decision variable transforms from **linear** -> **categorical**



6 Processing delay

- Reaction time latency correlates with **feature processing delay**
- The processing system is not ballistic



7 Conclusions

- The brain achieves object recognition by deriving increasingly abstract representations, using a spatio-temporal hierarchy
- Representations converge over time using recurrent connections
- The brain is adaptive, and can delay processing stages at will

Ambiguity is resolved by accumulating evidence with a cascade of dynamic processes

* for a focused comparison between the human brain and deep neural networks, see Gwilliams & King (2017) NIPS workshop on Cognitively Informed AI

[1] DiCarlo, J. J., D. Zoccolan and N. C. Rust (2012) [2] Gold, J. I. and M. N. Shadlen (2007)