Identifying The Neural Architecture of Perceptual Decision Making with Normative, Shallow and Deep neural network approaches

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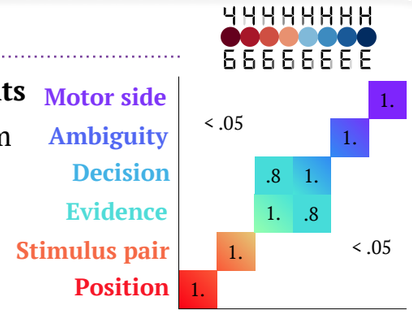
1 Introduction

- Object recognition recruits a **hierarchy** of cortical regions [1] and evokes a rapid feedforward response [2]

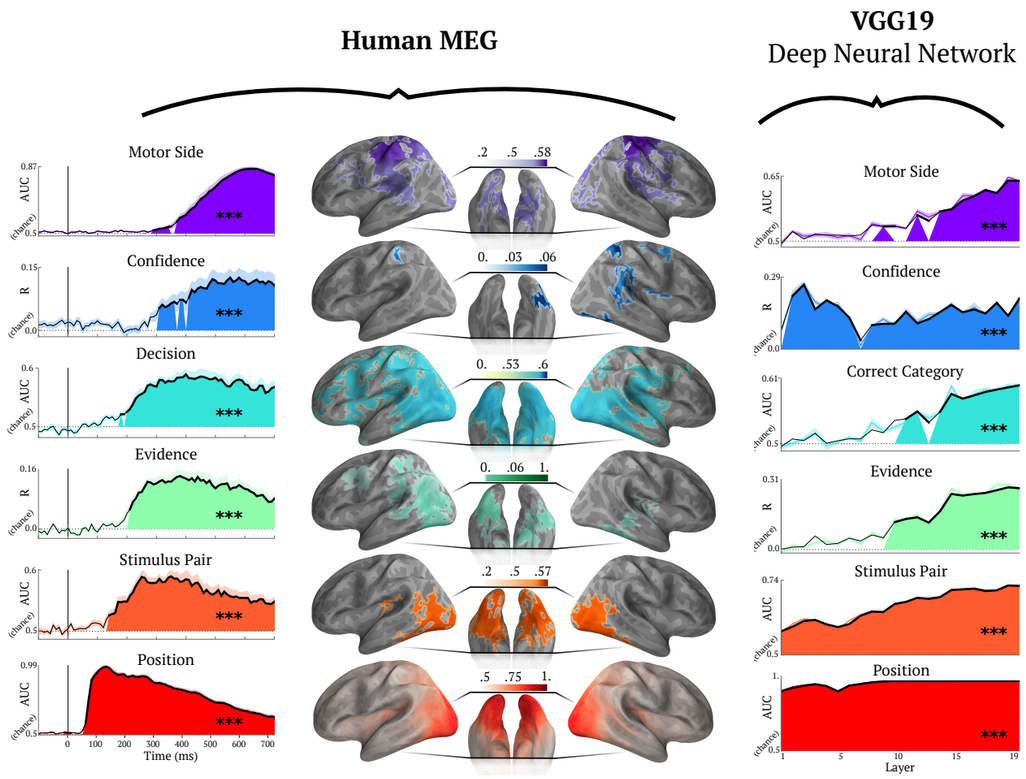
What neural mechanisms transform sensory input into perceptual experience?

2 Method & Analysis

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

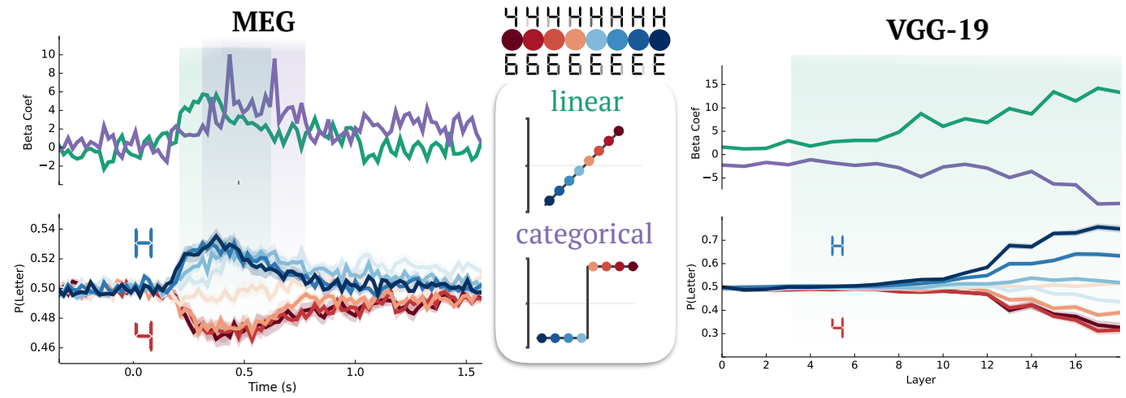


3 Temporal and spatial hierarchy: Comparing biological and artificial neural networks



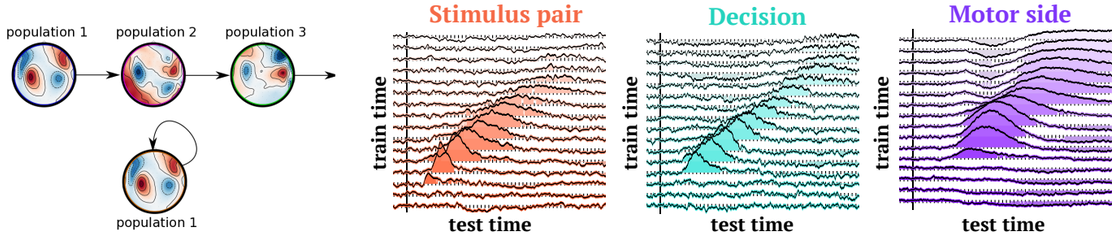
4 Tracking the neural computations performed at the decisional stage

- Sensory evidence of the *static* stimulus is **accumulated over time**
- In the human brain, representation of decision variable transforms from **linear** -> **categorical**
- DNN remains linear



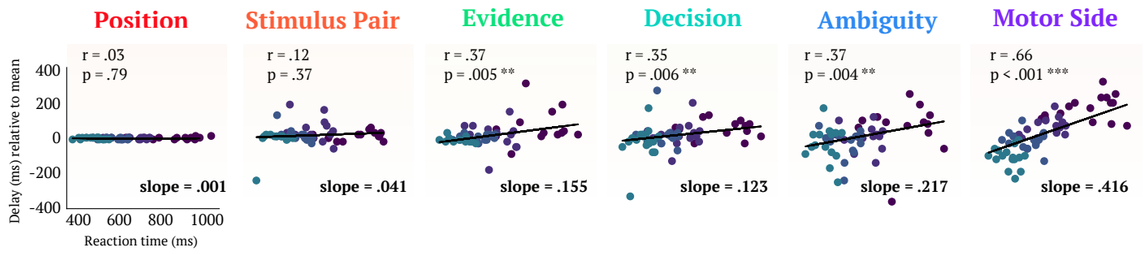
5 Testing for feedforward and recurrent architectures in the human brain

- A **sequence of operations** underlies the processing of a particular stimulus property



6 How are processing stages linked to one another to carry information

- Processing delay accumulates through the processing stages: The **output of one process is the input to the next**



7 Conclusions

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

* 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)