

# Modeling Task Effects on Meaning Representation in the Brain via Zero-Shot MEG Prediction

Mariya Toneva\*  
mktoneva@cs.cmu.edu

Otilia Stretcu\*  
ostretcu@cs.cmu.edu

Barnabás Póczos  
bapoczos@cs.cmu.edu

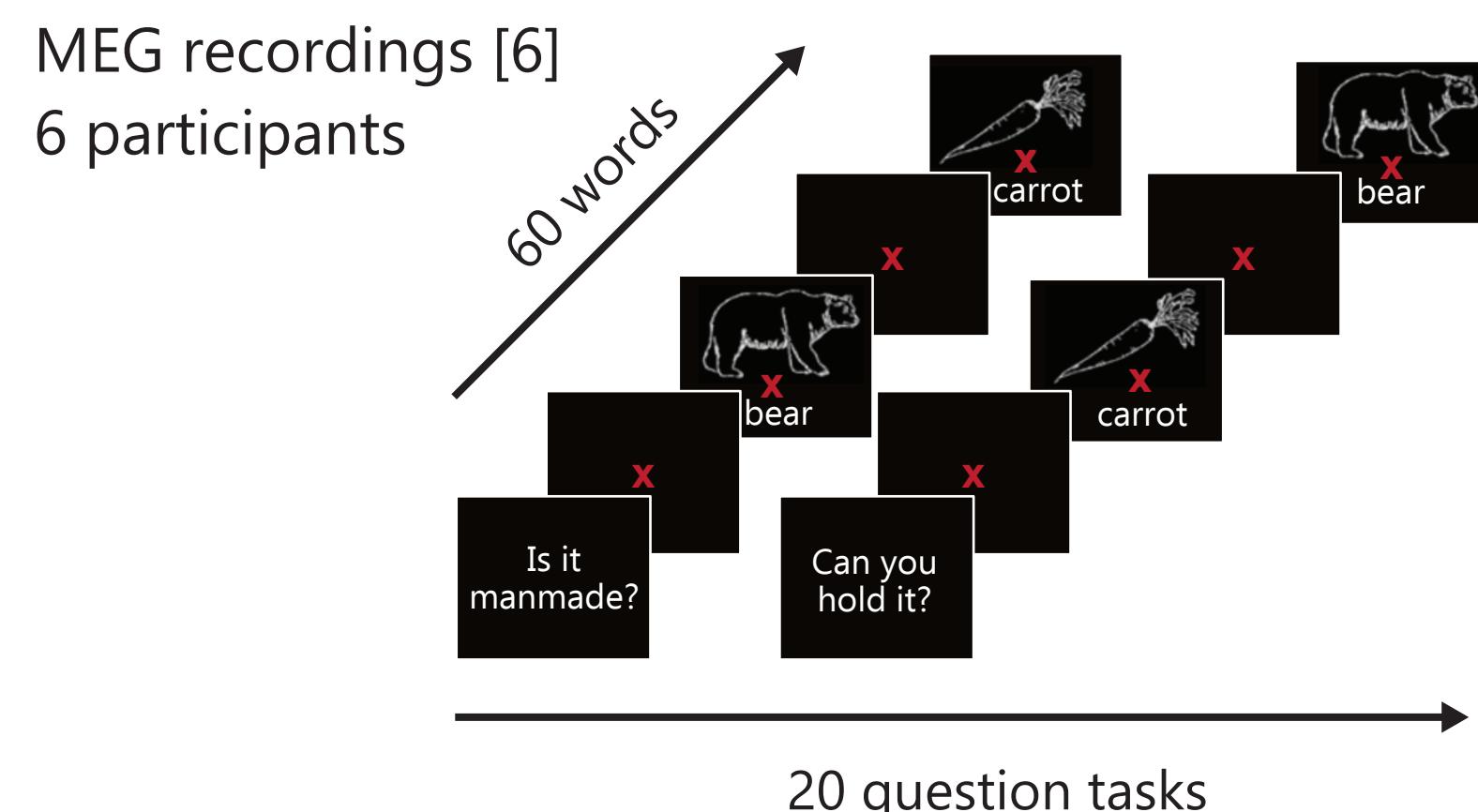
Leila Wehbe  
lwehbe@cs.cmu.edu

Tom M. Mitchell  
tom.mitchell@cs.cmu.edu

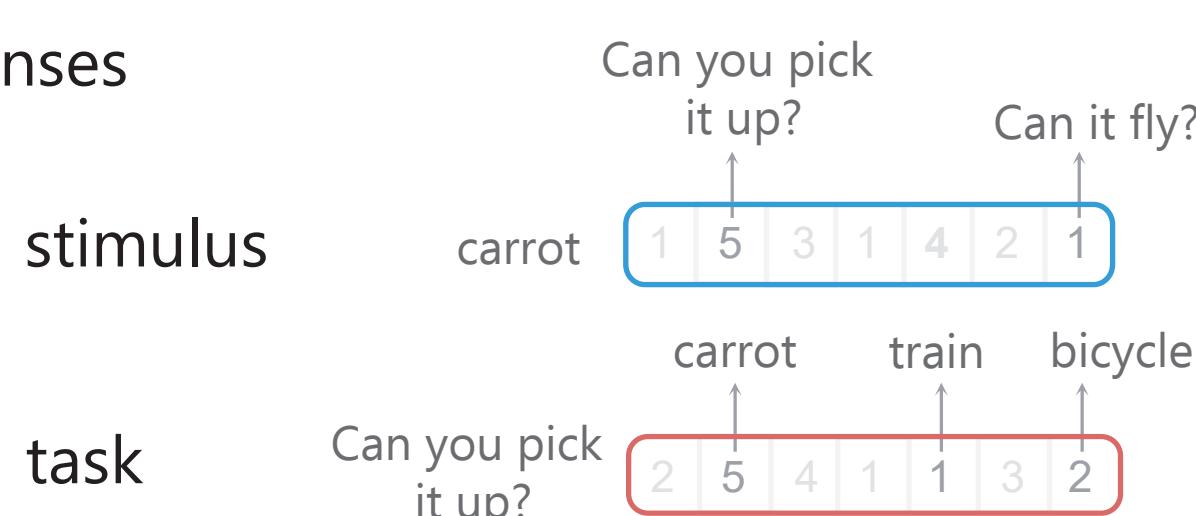
## Summary

- The brain activity elicited by the same stimulus while performing different tasks shows systematic differences [1-5]. How the task contributes to these differences is still unknown
- We propose the first computational model that **predicts brain activity as a function of both the stimulus and the task**
- We learn to predict brain activity in a **zero-shot** setting to enable generalization to new tasks & stimuli
- The **task effect coincides with the end of semantic processing** of the stimulus

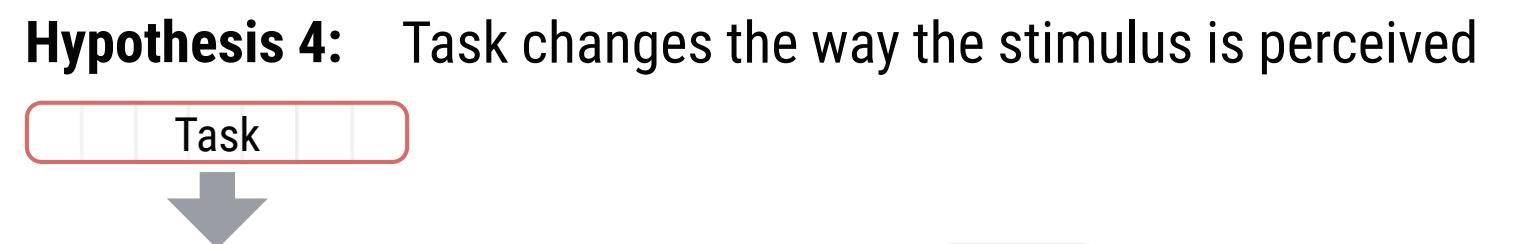
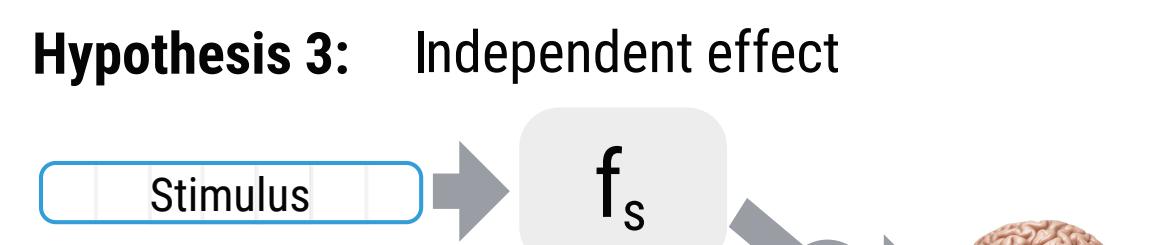
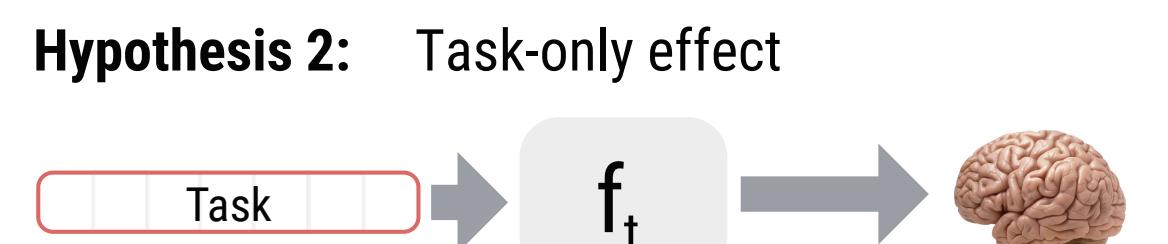
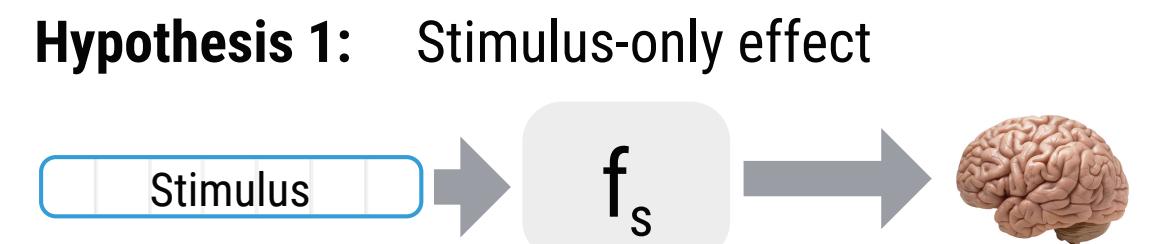
## Data



Mechanical Turk  
question responses



## Task Effect Hypotheses



true brain activity  
 $\ell(x, y) = \|y - f_\theta(x)\|^2 + \lambda\|\theta\|^2$

predicted brain activity

regularization on the regression parameters

learnt task-dependent attention weights

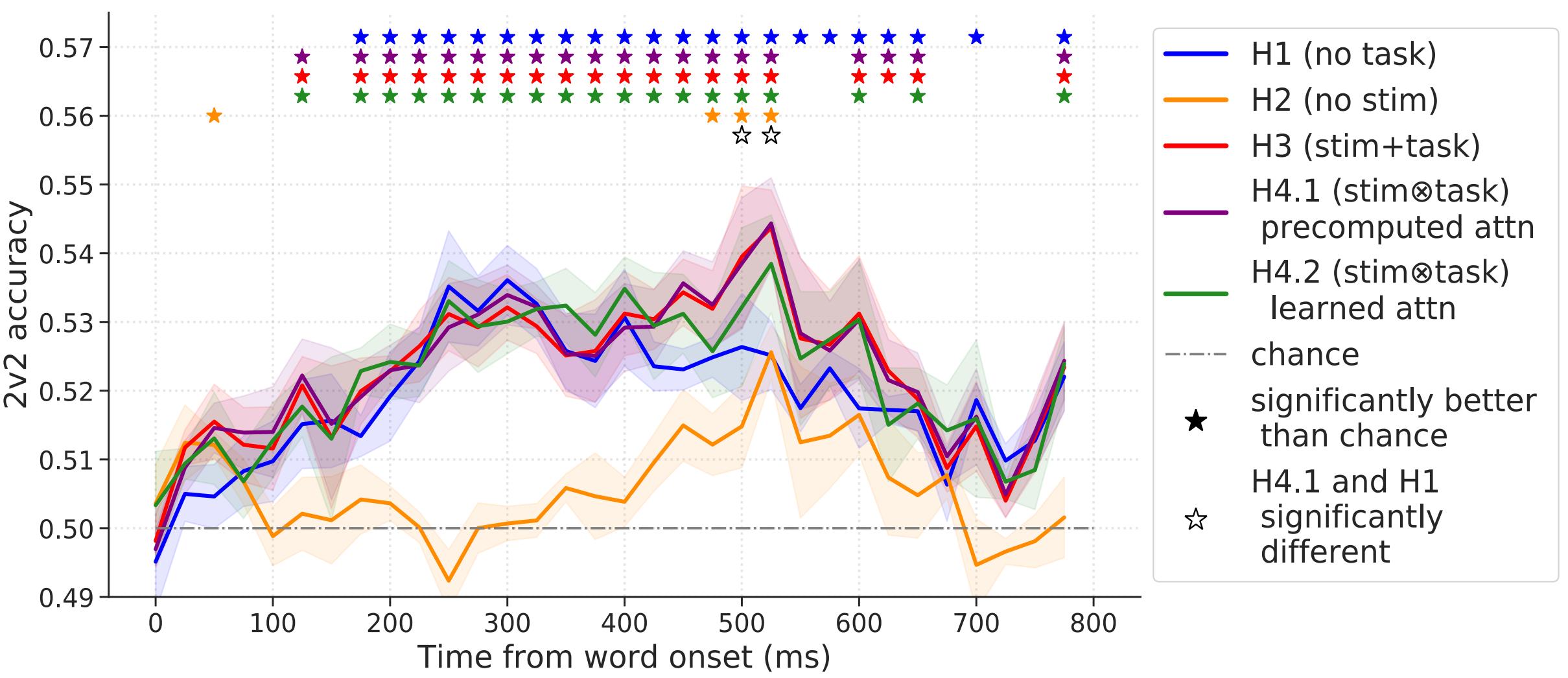
$H1: x = s$

$H2: x = t$

$H3: x = [s; t]$

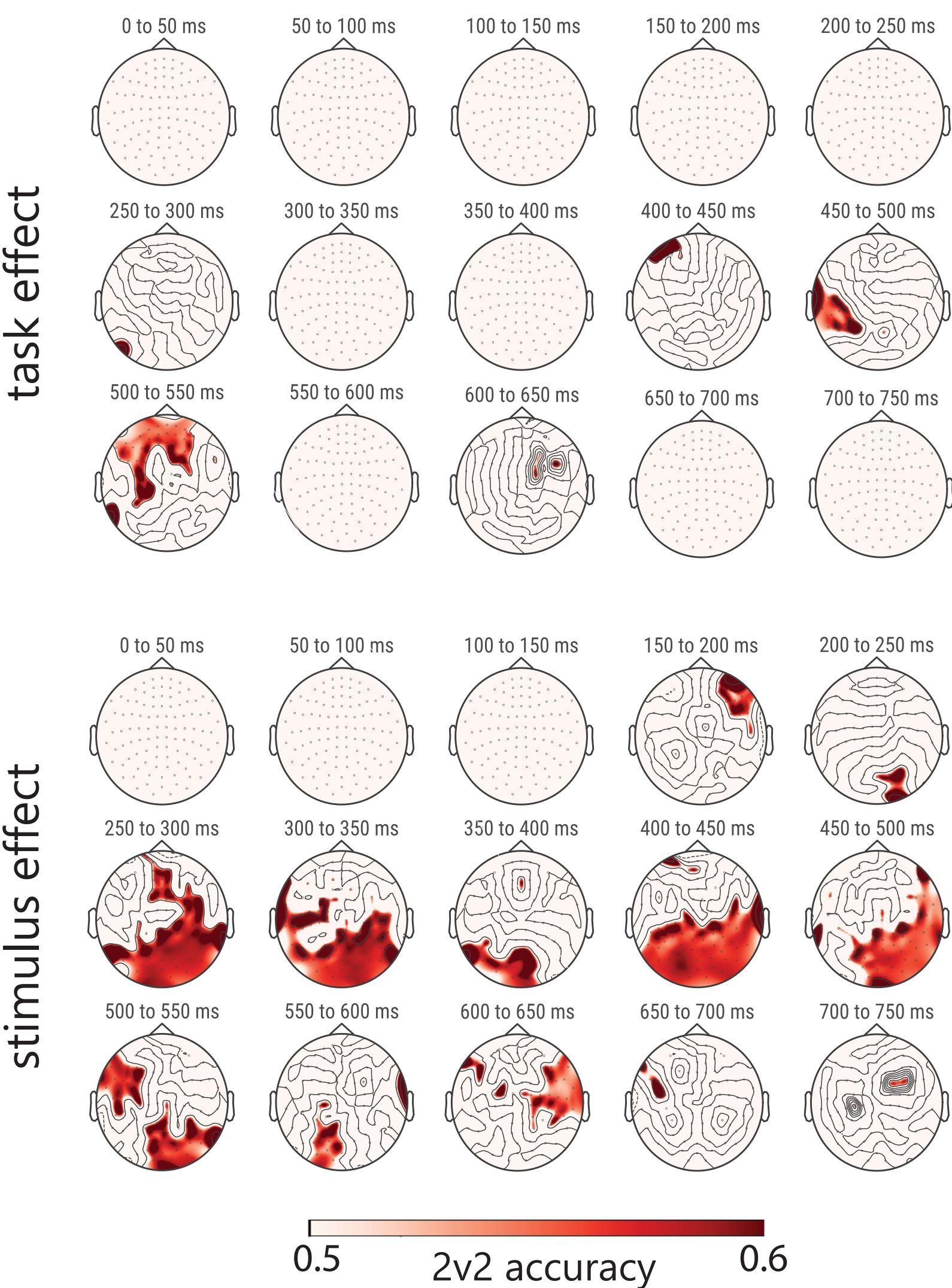
$H4: x = g(s, t) = \bar{s} = A_t s$

## Hypotheses Prediction Performance



Incorporating question task semantics improves predictions

## Task vs. Stimulus Effect



Task effect coincides with end of semantic word processing

## References

- [1] Hebart et al. 2018, eLife
- [2] Xu et al. 2018, Journal of Neuroscience
- [3] Wang et al. 2018, Scientific reports
- [4] Brouwer and Heeger 2013, Journal of Neuroscience
- [5] Cukur et al. 2013, Nature Neuroscience
- [6] Sudre et al. 2012, NeuroImage

Code: [github.com/otiliastr/brain\\_task\\_effect](https://github.com/otiliastr/brain_task_effect)