Neural representations of mental states remain stable across modalities and targets

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Introduction

Do we think about our own happiness in the same way as a stranger's?

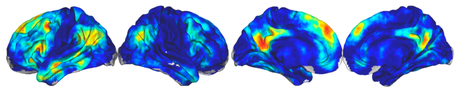
Does reading about a person's suffering elicit the same thought as seeing their face in pain?

We answer these questions by comparing neural activity in two studies with varying targets and modality, with previous research on mental state representation[1].

Hypotheses

Stability across targets
If people think about a mental state similarly, no matter who is experiencing it, *then* patterns of neural activity should remain stable when considering the mental states of different targets – *self/close/far other vs generic other*

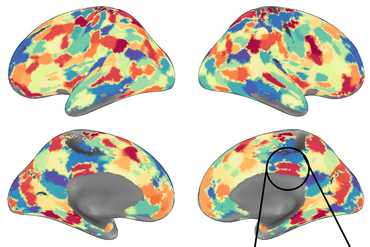
Stability across modalities
If a mental state is understood in the same way whether it is processed verbally or visually, *then* patterns of neural activity should remain stable when presented in different modalities – *lexical vs. pictorial stimuli*



Map of mental state reliability from Control[1]

Analyses

200+ ROIs based on coherent topics from Neurosynth[2]

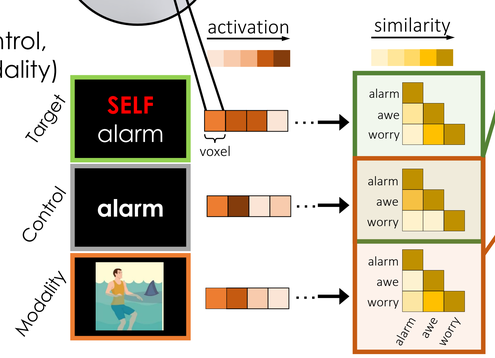


Patterns of similarity from distinct datasets were correlated

- Bootstrapped participants in both relevant datasets (Control, Target or Modality)
- Calculated correlation means, confidence intervals
- Bonferroni-corrected

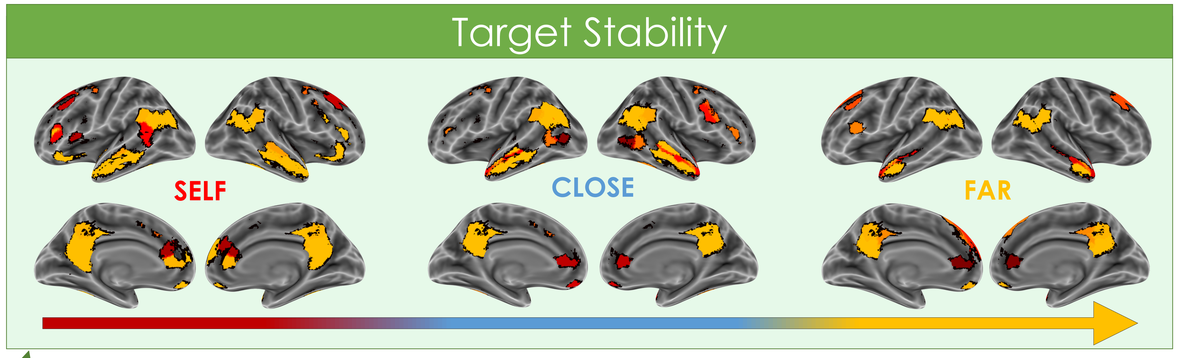
Within each ROI:

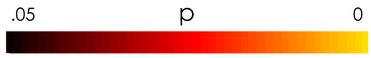
1. Within each study, pattern similarity matrices across mental states were calculated
2. Between studies, similarity matrices were correlated
   - within targets between **Control** and **Target**
   - across targets between **Control** and **Modality**



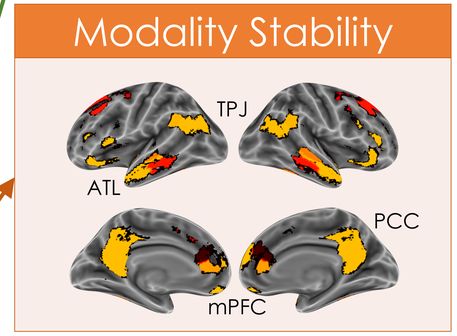
Results

Target Stability





Modality Stability



Compared to previous findings, two new and distinct datasets show significant ($p < 0.05$) correlations within mental states and across:

- *Targets*: three levels of social distance from the self compared to a generic other (above)
  1. Self (the participant)
  2. Close (a similar, familiar other)
  3. Far (a dissimilar, unfamiliar other)
- *Modalities*: pictorial stimuli compared to lexical stimuli (left)

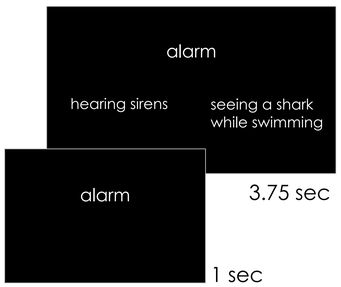
Methods

In each study, participants imagined targets experiencing various mental states. On each trial, the mental state appeared first, followed by two scenarios that typically elicit that state.

Individual Trial

Control[1]

Modality: Lexical
Target: Generic other

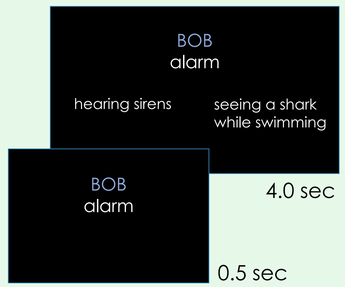


16 runs
60 mental states/run

N=20 (4M, 16F; 18-27yrs, mean age = 22.7yrs)
3T Siemens Trio Scanner, 32-channel headcoil

Target Study

Modality: Lexical
Targets: Self, Close, Far

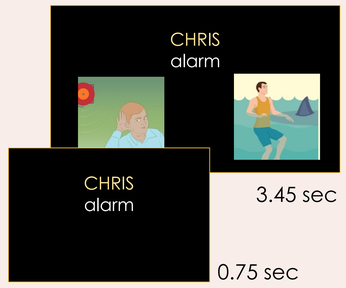


12 runs
3 targets/run
25 mental states/target/run

N=35 (12M, 23F; 18-31yrs, mean age = 21yrs)
3T Siemens Prisma Scanner, 64-channel headcoil

Modality Study

Modality: Picture
Targets: Self, Far



12 runs
2 targets/run
30 mental states/target/run

N=30 (15M, 14F; 19-27yrs, mean age = 20yrs)
3T Siemens Prisma Scanner, 64-channel headcoil

Discussion

Brain regions previously associated with mental state representation show stable patterns of activity across targets and stimulus modalities.

People hold stable representations of mental states, whether considering yourself, a friend, or a stranger.

People think about people experiencing mental states in the same way, whether they they read about them or visually see the experience.

The context in which a mental state occurs is extremely diverse. Yet, people seem to hold a core understanding of what each mental state is, and what it's like to experience it, across these differences.

References

Thank you to NIH Blueprint for Neuroscience (Research Training Grant T90DA022759), NIMH (R01MH114904), Graduate Research Fellowships from NSF (DGE 1144152), and The Sackler Scholar Programme in Psychobiology at Harvard University.

[1] Tamir, D.I.*, Thornton, M.A.*, Contreras, J.M., Mitchell, J.P. (2016). Neural evidence that three dimensions organize mental state representation: rationality, social impact, and valence. Proceedings of the National Academy of Sciences, 113(1), 194-199.

[2] *de la Vega, A., Chang, L.J., Banich, M.T., Wager, T.D., & Yarkoni, T. (2016). Large-Scale Meta-Analysis of Human Medial Frontal Cortex Reveals Tripartite Functional Organization. Journal of Neuroscience, 36(24), 6553– 6562.*