Neural representations of faces are widely distributed and highly individualized

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A distributed neural code for faces

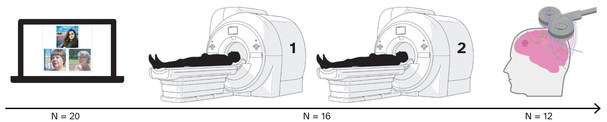
Face processing long assumed to be modular (e.g. FFA, PPA)[1]

Increasing evidence for distributed neural ensembles[2a,2b]

Decoding content ≠ causal relevance for content processing

How can we tell that distributed representations really matter?

Session 1 | **Sessions 2 & 3** | **Session 4**



N = 20 | N = 16 | N = 12

Triad task
Recruited from UW-Madison and surrounding community
Aged 18-35 (M=26.3 years)

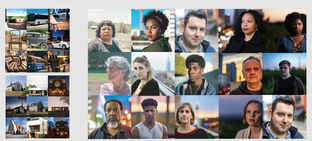
fMRI task
3T GE scanner
12, 6.5-minute EPIs (~1.5 hours/scan)
Two scans per participant, weeks apart
Same task both scans

TMS task
MagStim Rapid2
10 Hz @ 40% power
Delayed triad task

Stimuli

32 items/domain
x2 sets
Dall-E 3 generated[3]

Parametric variation binarized attributes



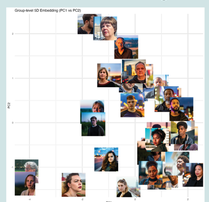
race (Black/white)
gender* (man/woman)
age (older/younger)
location (urban/rural)
time (day/evening)

*We acknowledge all gender identities

Triad task: Capturing mental organization of faces[4]

Triadic comparisons → Ordinal embeddings → Predicting "attended attributes"

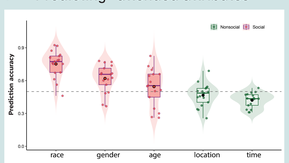
600 trials/participant
200 trials/domain



2-5 dimensional embedding group and individual-level

↓

mental representation similarity



Participants make similarity decisions based on social attributes

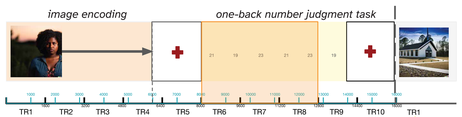
logistic regression to predict image attributes from embedding coordinates

Are neural representations of faces distributed, stable, and idiosyncratic?

***Distributed*:** Can we find reliable category information beyond canonical processing areas?

***Stable*:** Are decoding solutions consistent within a person across time (e.g., scans weeks apart)?

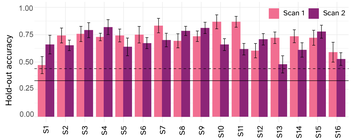
***Idiosyncratic*:** Are decoding solutions transferable to another person?



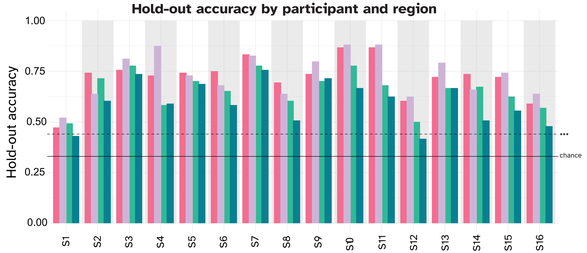
Instructions: Study images very carefully; you will be tested on your memory

We can predict stimulus face/place/object category from all participants

IteratedLASSO[5] on max BOLD TRs
10 "runs" of max. 10 iterations
Keep voxel sets predicting >33%



Distributed? We find face/place/object information outside of canonical processing areas



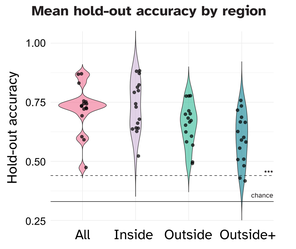
Restrict decoding to:

All cortical regions

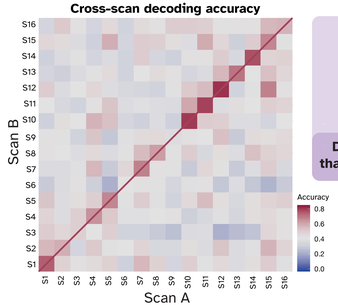
Inside[6] FFA, PPA, LOC

Outside no FFA, PPA, LOC

Outside+ no FFA, PPA, LOC +5mm radius



Stable and idiosyncratic? Decoding solutions are consistent across time, but not across people



Bipartite graph matching[7]

For each voxel in decoding solution:

1) Find closest anatomical match

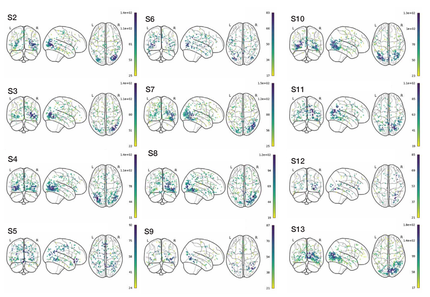
Within ID: scan 1 → scan 2
Between IDs: scan 1 → scan 1

2) Decode from matched voxels

Decoding from self is 23% better than decoding from others, p < .00004

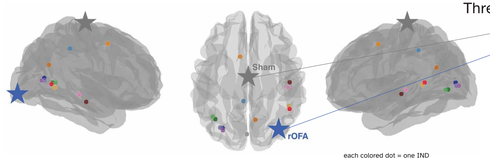
Finding "hotspots"

Identify voxel areas with high number of selected neighbors (20mm radius) common across both scans



...and causally recruited in a face processing task?

Transcranial magnetic stimulation (TMS)[8] can reveal whether non-canonical, individualized neural regions are causally relevant for face processing (i.e. mirroring canonical area RT and accuracy patterns)



Three stimulation sites per participant:

Sham control (vertex)

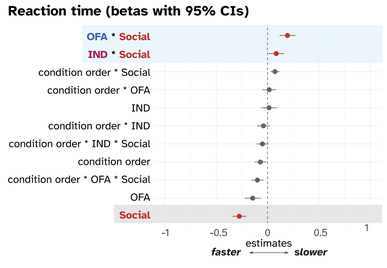
Shared occipital face area (OFA)

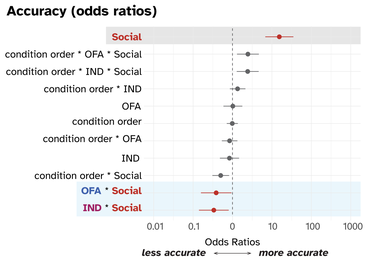
Individualized face area (IND)

Consistently selected in both scans
Outside of canonical areas
Priortize face "hotspot" regions
TMS-able (close to surface of the skull)

unlimited response time; minimum 5 seconds between trials
96 trials/block; one block per stimulation site, order counterbalanced

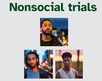
Causal? Stimulation to individualized region impedes face processing





Coded with reference to sham condition, nonsocial trials; LMEMs with condition order as covariate (learning/fatigue effects); by-item and by-subject random effects

Nonsocial trials



normally slow
normally less accurate

Social trials

normally fast
normally accurate

Stimulation to both OFA and IND significantly impacts face processing

stimulation slows
stimulation worsens

References & Acknowledgments

1. Kanwisher (2001)
2. McClelland and Rogers (2003); Haxby, Connolly, and Guntupalli (2014)
3. Betker et al. (2023)
4. Colón and Rogers (2025)
5. Li, Colón, Mukherjee, and Rogers (2025)
6. Julian, Fedorenko, Webster and Kanwisher (2012)
7. Li et al. (2020)
8. Pascual-Leone, A., Walsh, V., & Rothwell, J. (2000)

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Questions/Comments?
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