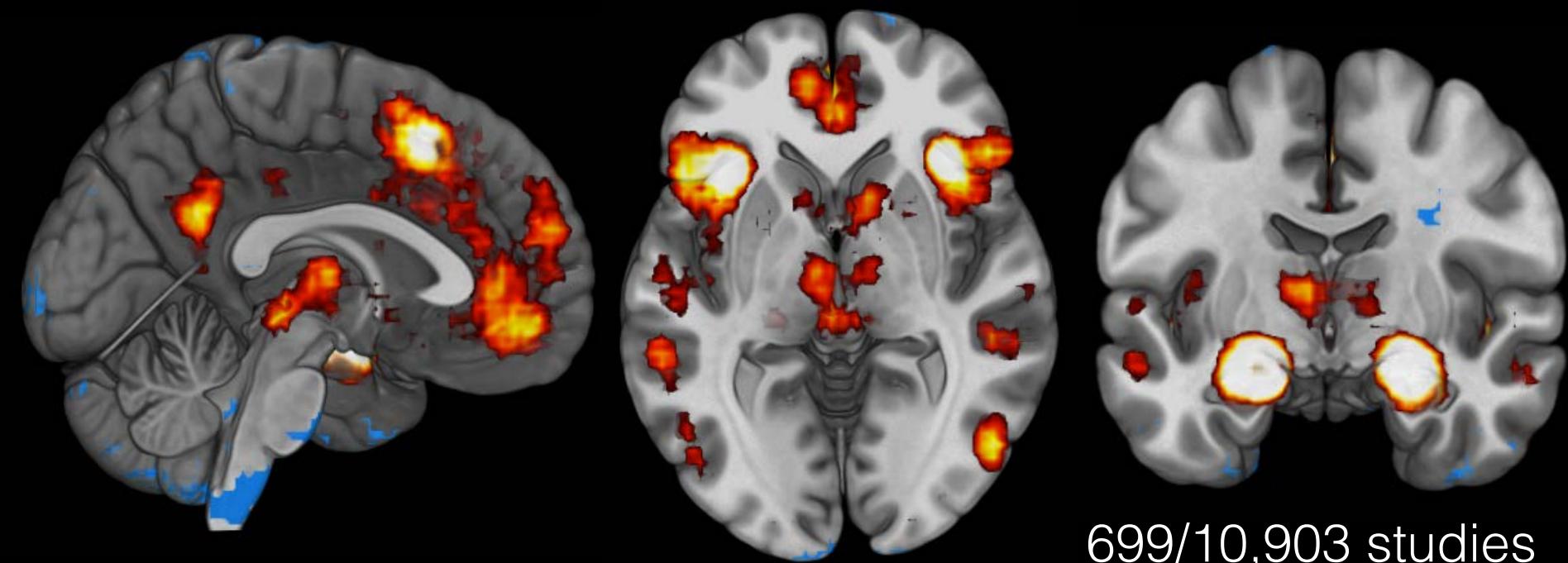


Construct Validity of Brain Representations

Luke Chang, PhD
Computational Social & Affective Neuroscience Laboratory
Dartmouth College

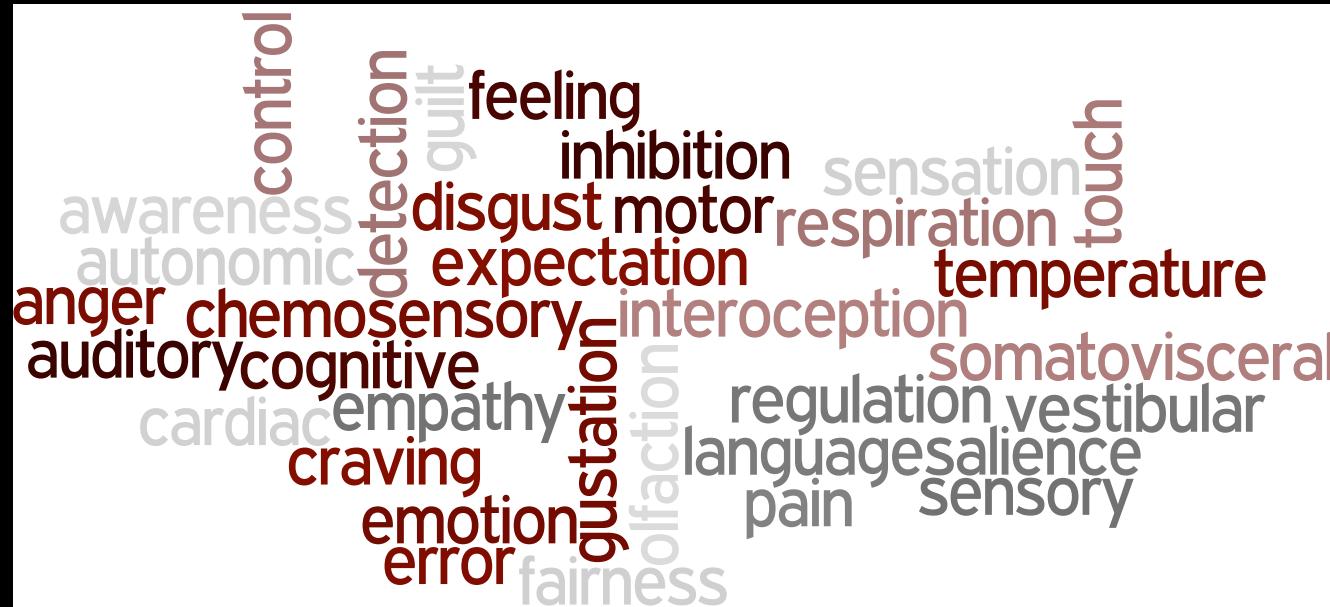
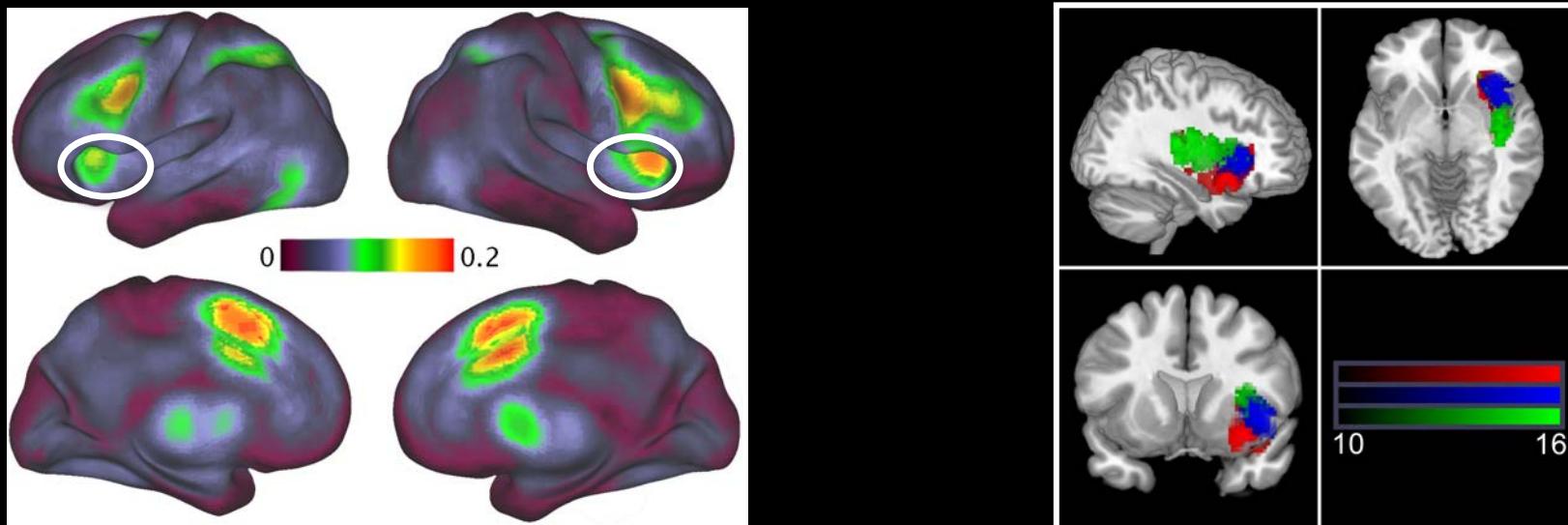


Many regions are **consistently** associated with emotion



699/10,903 studies
<http://neurosynth.org>

But, which regions specifically process emotion?

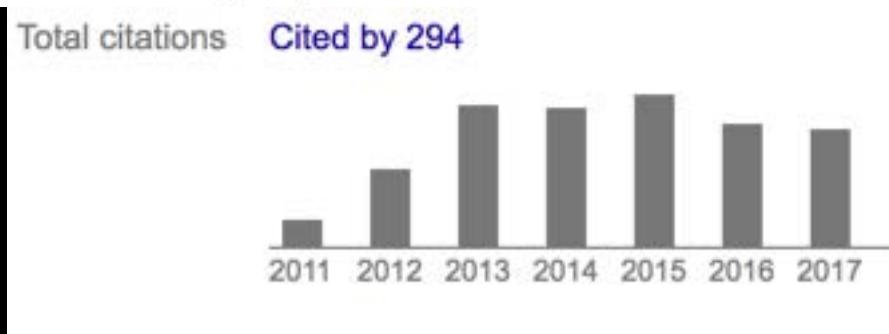


Chang, Yarkoni, Khaw & Sanfey (2013) Cerebral Cortex

LPT: Don't worry about being scooped (You don't need to be first)

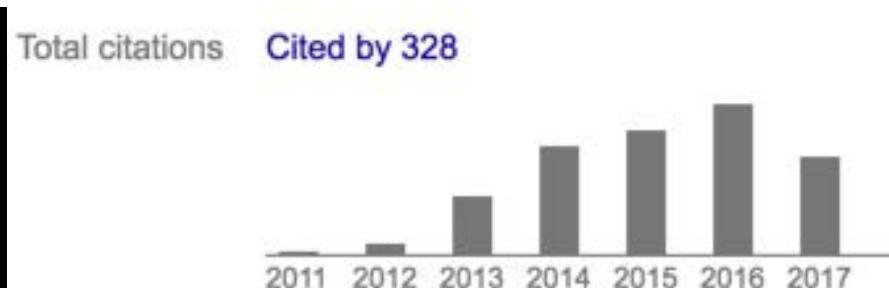
Three Systems of Insular Functional Connectivity Identified with Cluster Analysis

Ben Deen, Naomi B. Pitskel and Kevin A. Pelphrey

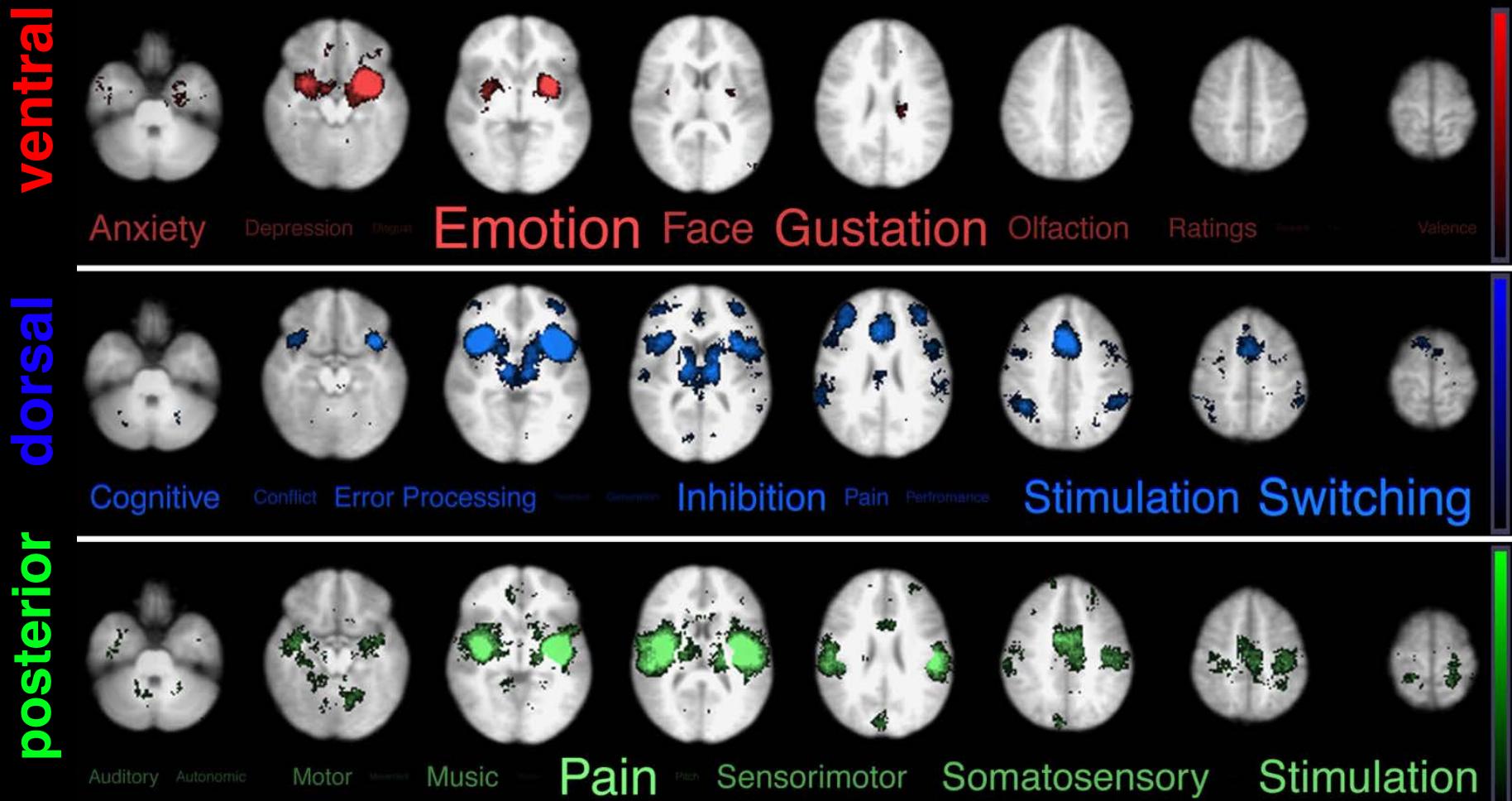


Decoding the Role of the Insula in Human Cognition: Functional Parcellation and Large-Scale Reverse Inference

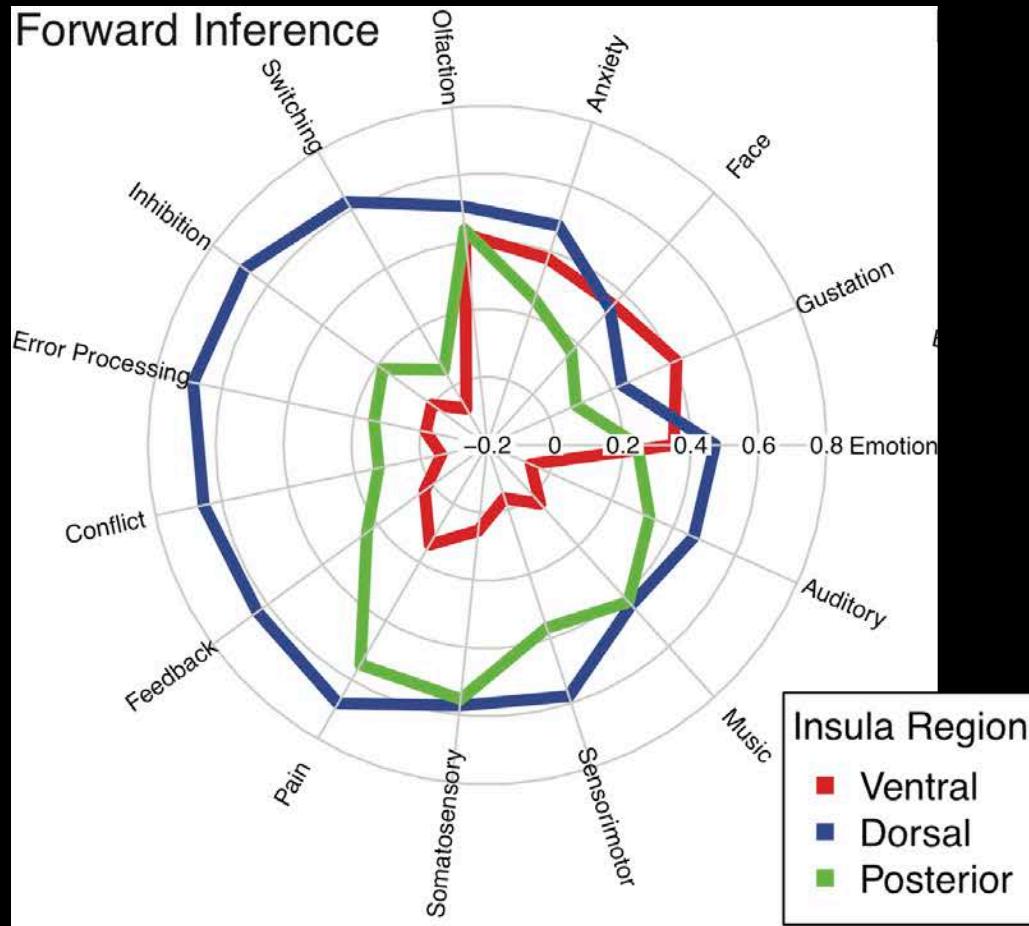
Luke J. Chang^{1,2}, Tal Yarkoni³, Mel Win Khaw⁴ and Alan G. Sanfey^{1,5,6}



Meta-Analytic Decoding



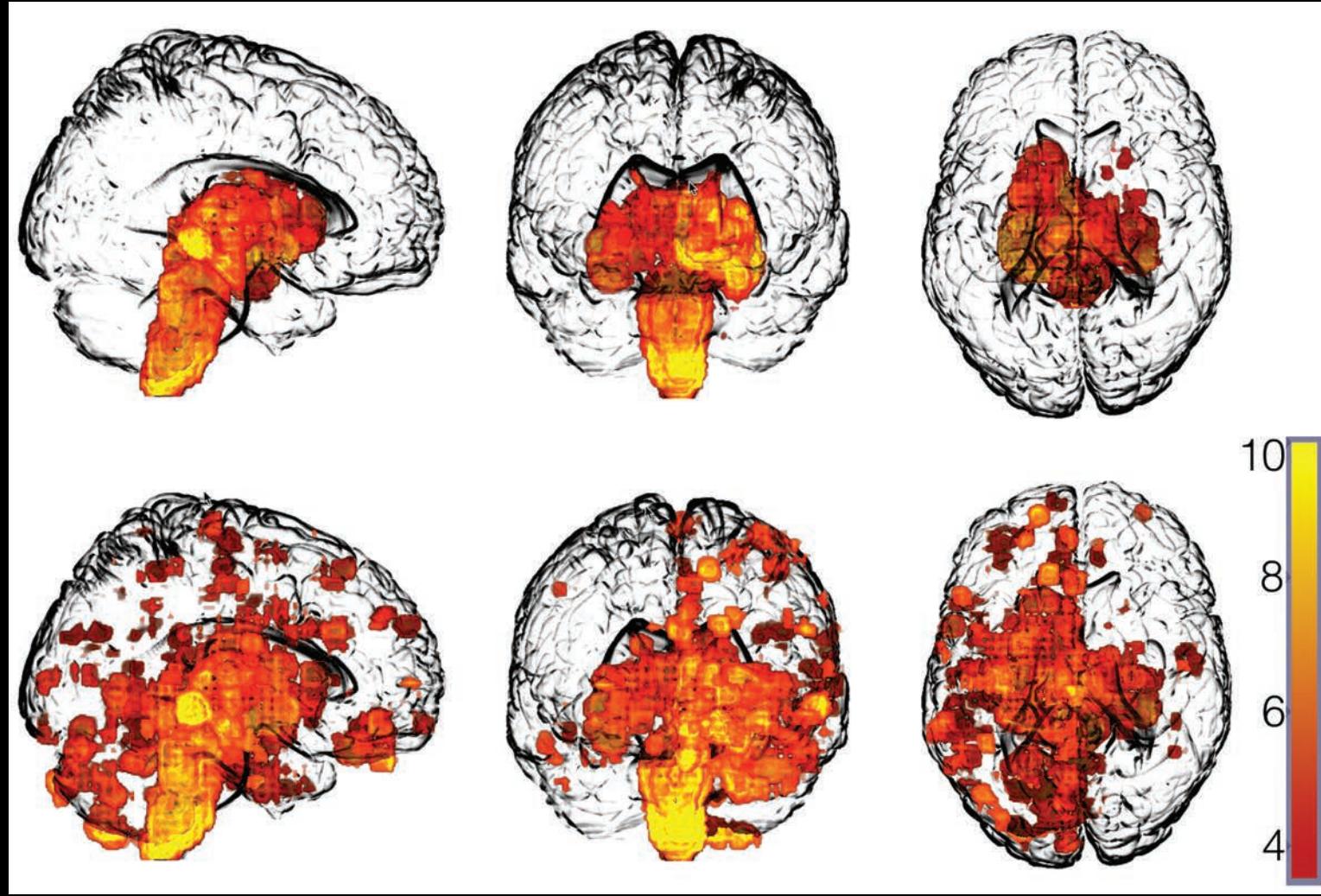
Consistency & Specificity



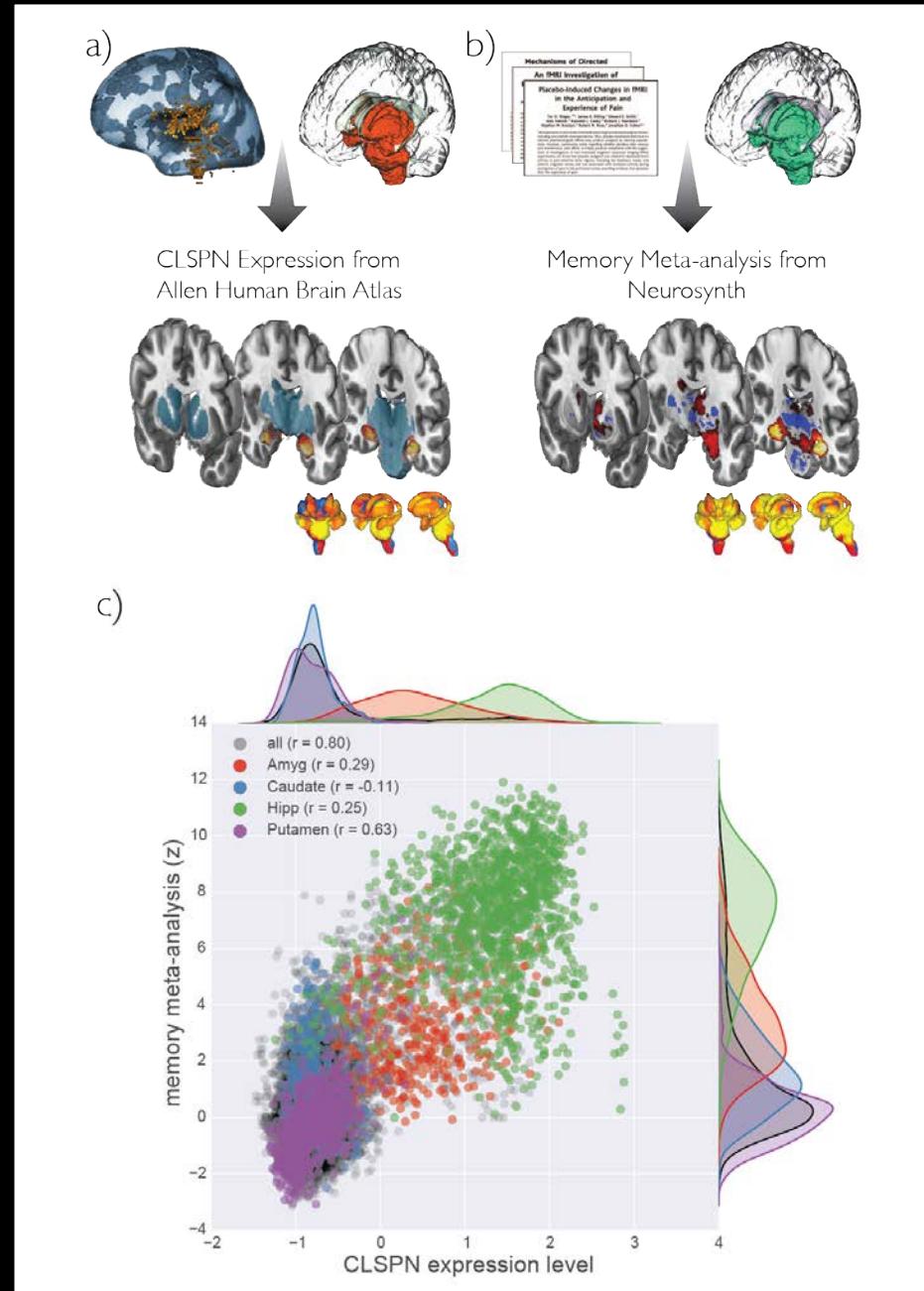
Chang, Yarkoni, Khaw, & Sanfey (2012) Cerebral Cortex

Other Decoding Applications

3,702 tissue samples across 6 human postmortem brains with 58,000 gene probes

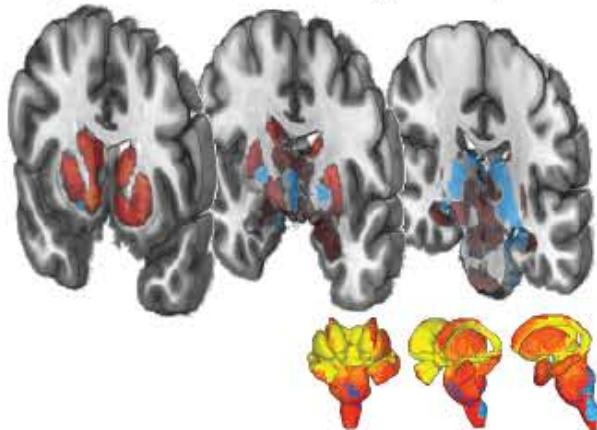


The Concept

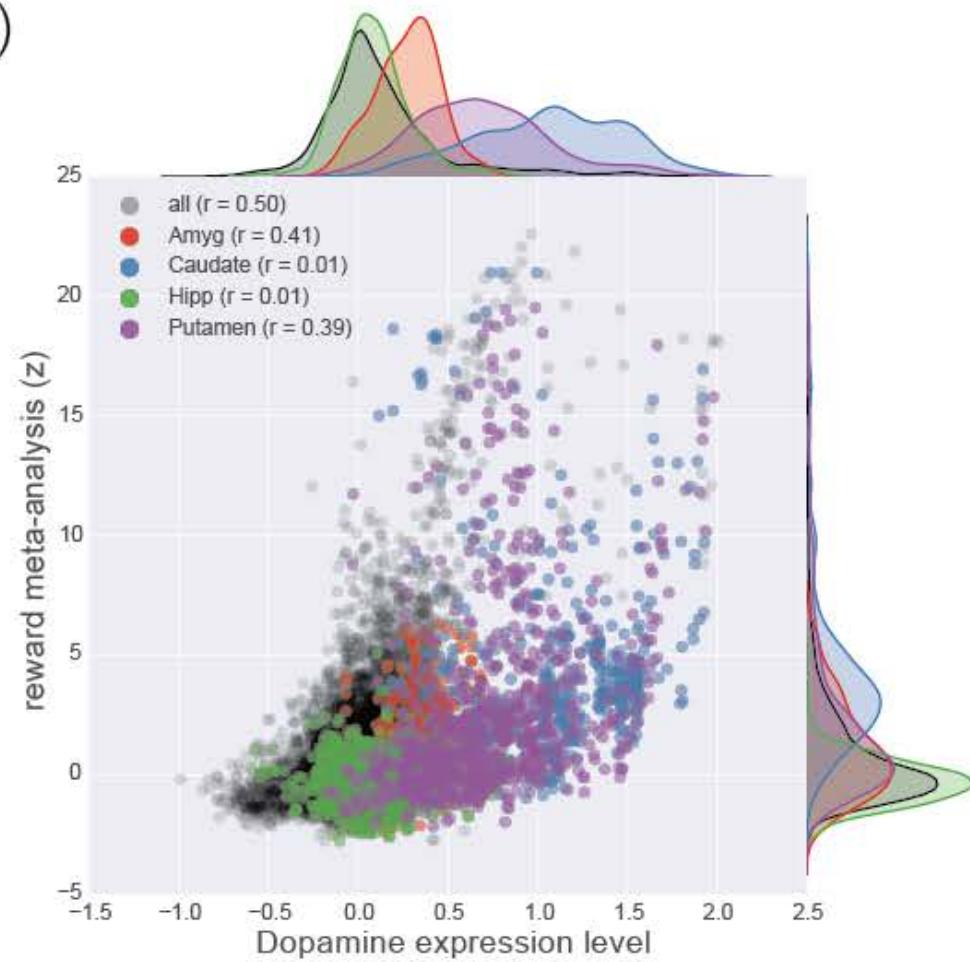
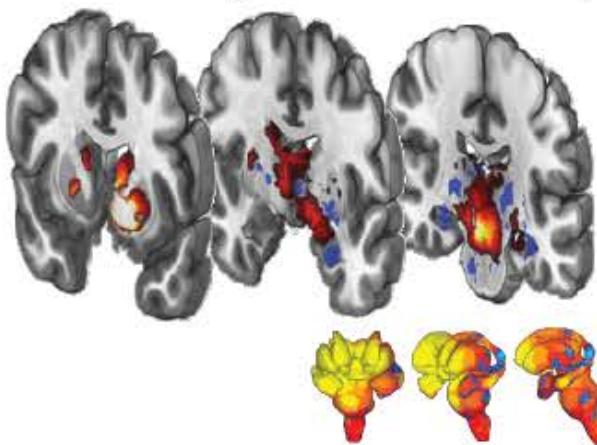


How do we know if it works?

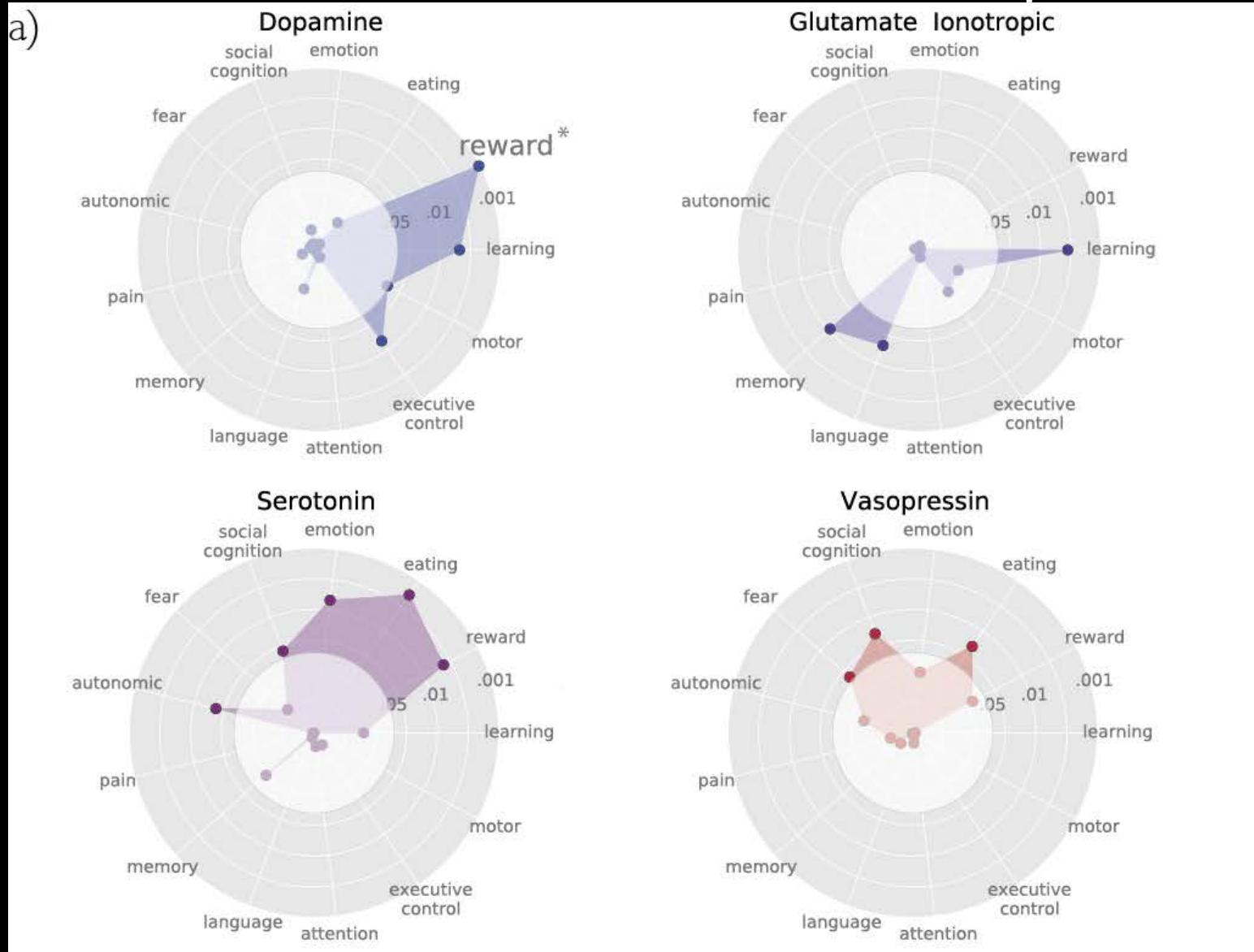
b) Dopamine-family Expression d)



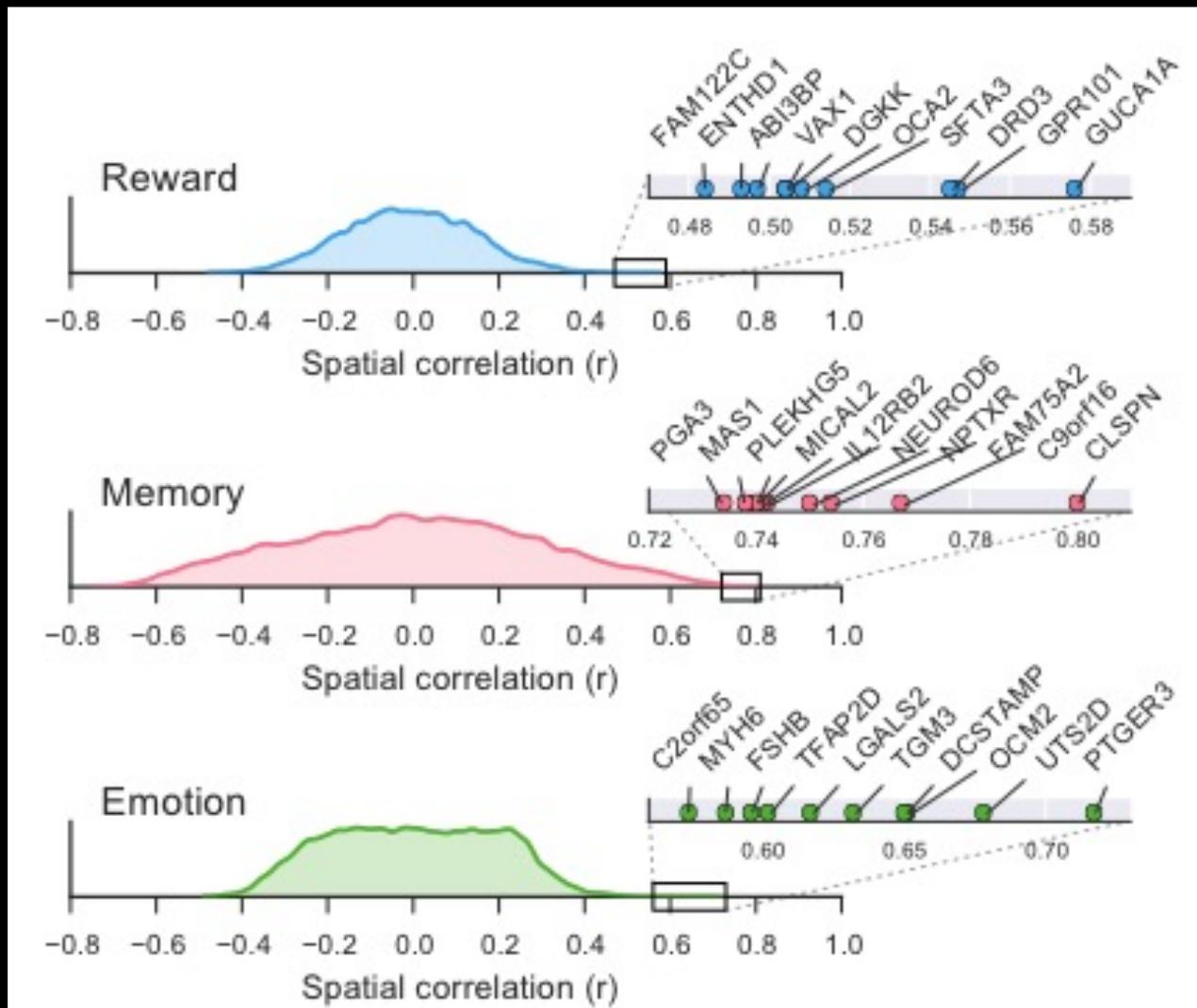
c) Reward topic meta-analysis



Neurotransmitter Groups



Which genes are good candidates?



Decoding can be misused

The dorsal anterior cingulate cortex is selective for pain: Results from large-scale reverse inference

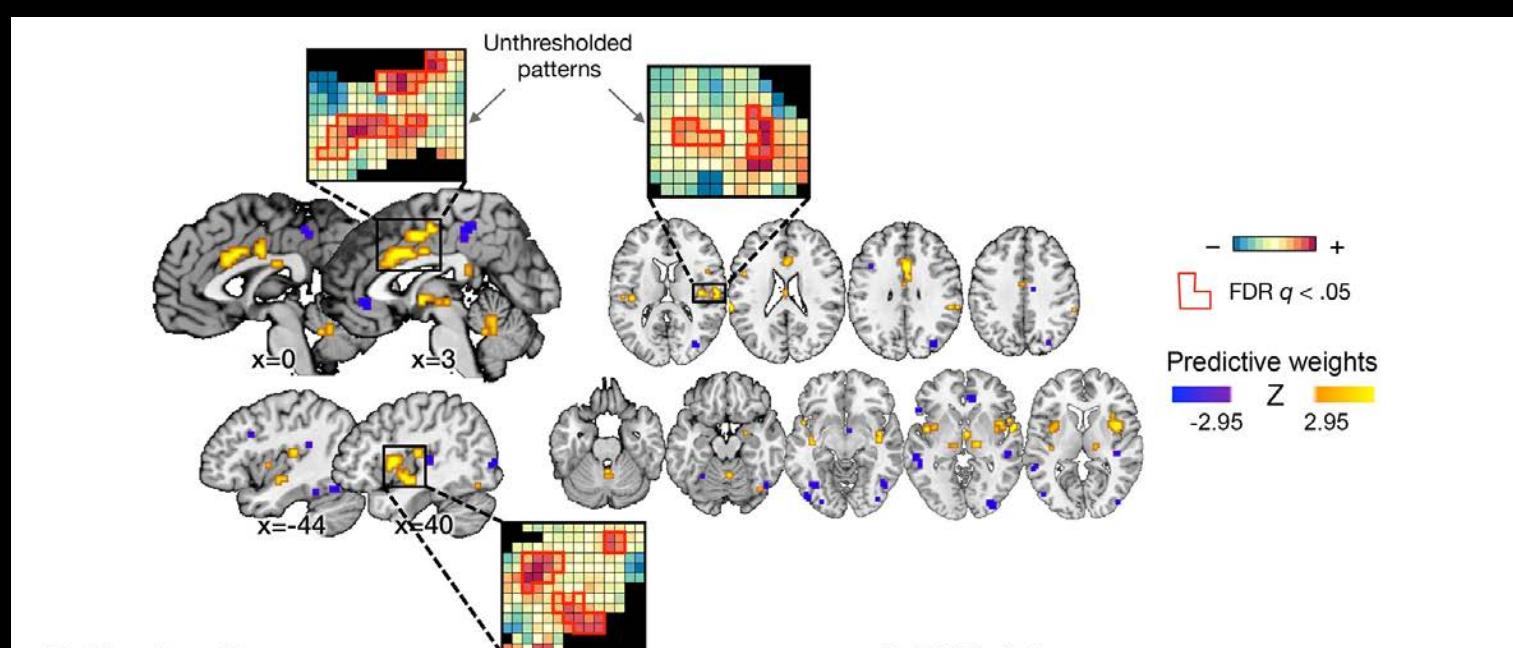
Matthew D. Lieberman¹ and Naomi I. Eisenberger

Pain in the ACC?

Tor D. Wager^{a,b,1}, Lauren Y. Atlas^{c,d}, Matthew M. Botvinick^e, Luke J. Chang^f, Robert C. Coghill^g, Karen Deborah Davis^{h,i,j}, Gian Domenico Iannetti^k, Russell A. Poldrack^l, Alexander J. Shackman^{m,n,o}, and Tal Yarkoni^p

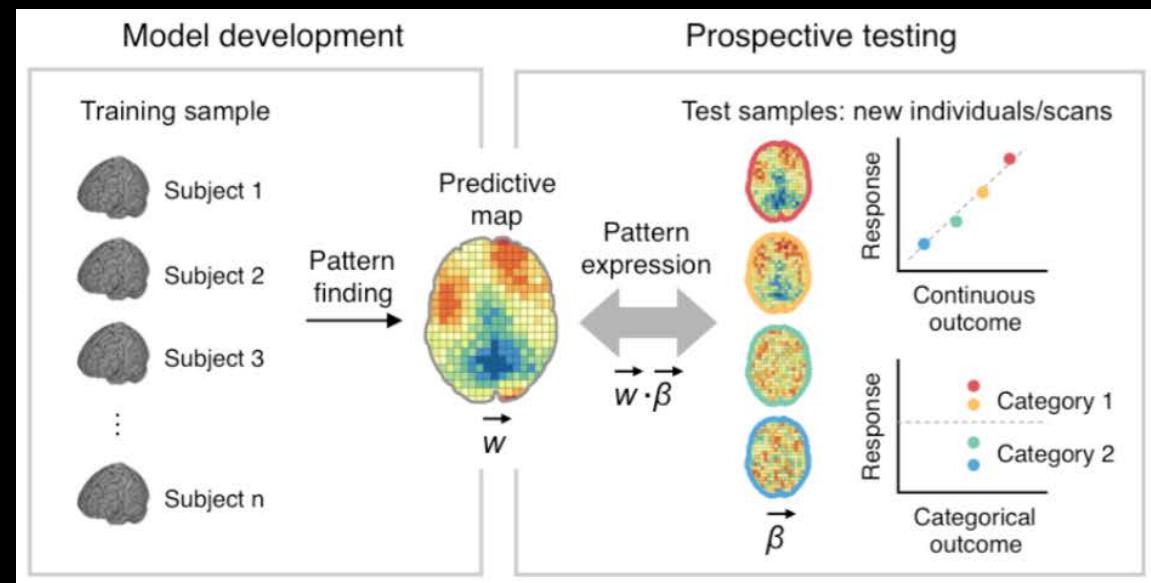
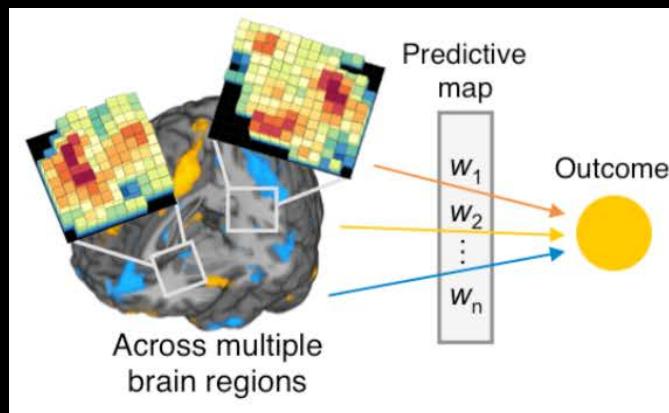
Neuroscientists Identify a Brain Signature of Pain

Brain scanning homes in on a neural signature for physical pain



Towards Predictive Models

- Precise model
- Sensitivity & Specificity at the individual person level
- Generalizability



Can this approach work for other affective states?

A Sensitive and Specific Neural Signature for Picture-Induced Negative Affect

Luke J. Chang^{1*}, Peter J. Gianaros², Stephen B. Manuck², Anjali Krishnan¹, Tor D. Wager^{1,*}

Somatic and vicarious pain are represented by dissociable multivariate brain patterns

Anjali Krishnan^{1,2,3*}, Choong-Wan Woo^{1,2†}, Luke J Chang^{1,2,4†}, Luka Ruzic^{1,2,5}, Xiaosi Gu^{6,7}, Marina López-Solà^{1,2}, Philip L Jackson⁸, Jesús Pujol⁹, Jin Fan^{10,11}, Tor D Wager^{1,2*}

Multivariate Brain Prediction of Heart Rate and Skin Conductance Responses to Social Threat

Hedwig Eisenbarth,^{1,2} Luke J. Chang,³ and Tor D. Wager¹

https://github.com/canlab/Neuroimaging_Pattern_Masks/tree/master/Multivariate_signature_patterns



Pete Gianaros
Steve Manuck
University of Pittsburgh



Anjali Krishnan
Brooklyn College



Tor Wager
University of Colorado



Neutral (n = 15)
Negative (n = 15)

Analysis Pipeline

Temporal Dimensionality Reduction via GLM

$$\text{Voxel Time Series} = \begin{bmatrix} \text{Rating} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{bmatrix} \cdot \beta_{\text{rating}}$$

C Train PINES via Cross-Validation (n=121)

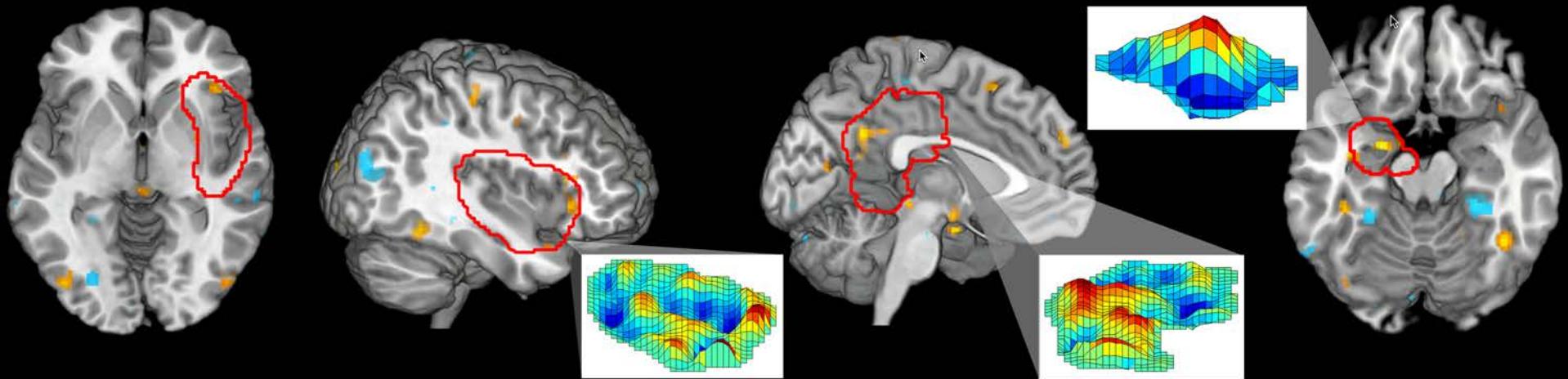
$$\text{Rating} = \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ \vdots \\ n \end{bmatrix} \cdot \beta_{\text{voxel}}$$

Test Pattern Response

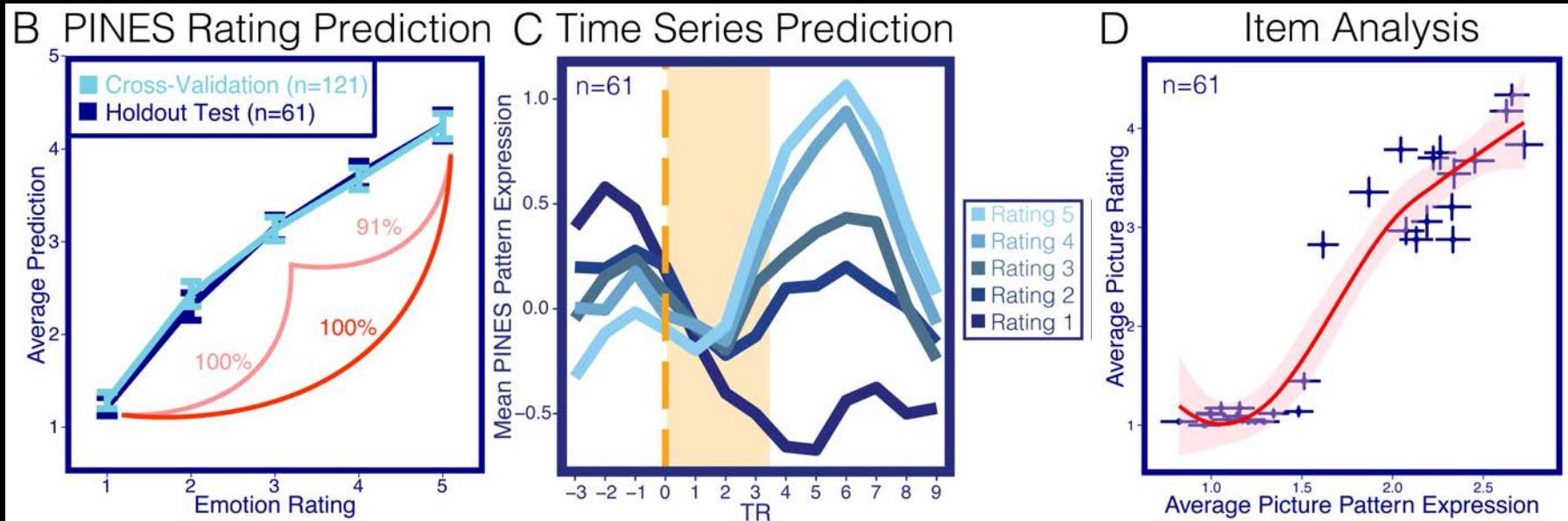
Predicted
Affective Rating

$$= \begin{bmatrix} \text{Pattern} \\ \text{Test Data} \end{bmatrix} \cdot \beta_{\text{voxel}}$$

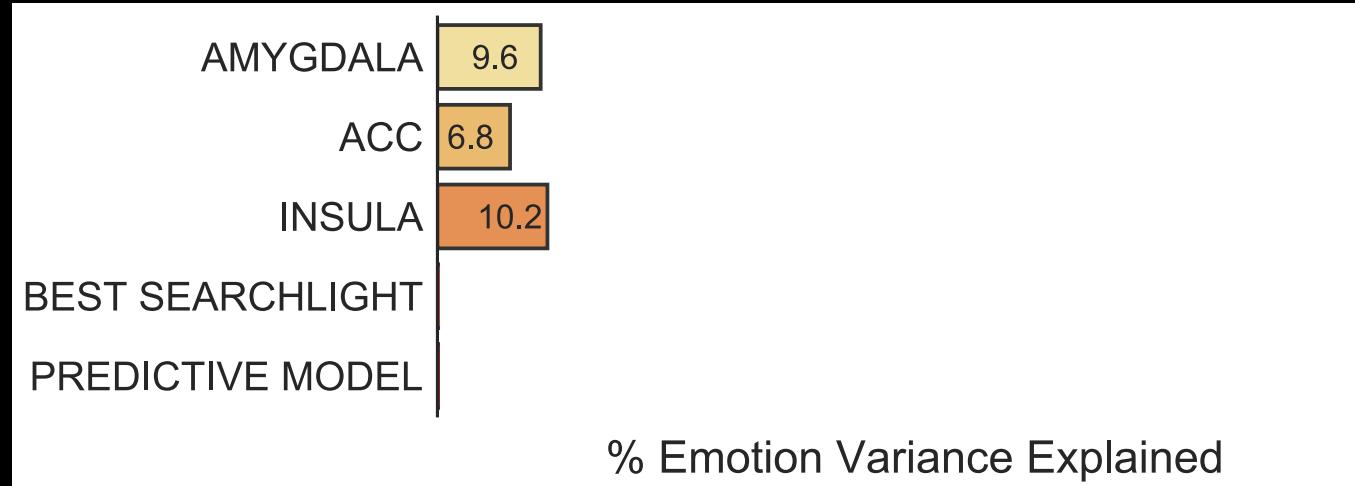
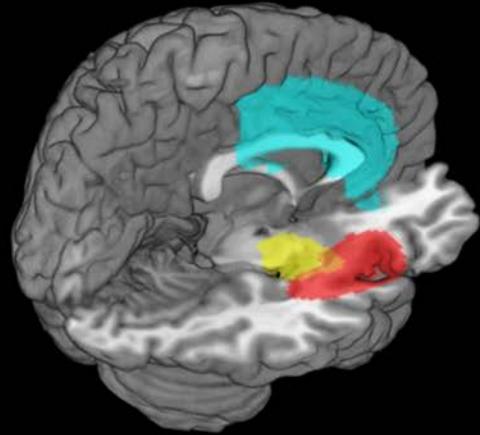
Picture Induced Negative Emotion Signature (PINES)



Validating PINES



Amount of Emotion Variance Explained by Model



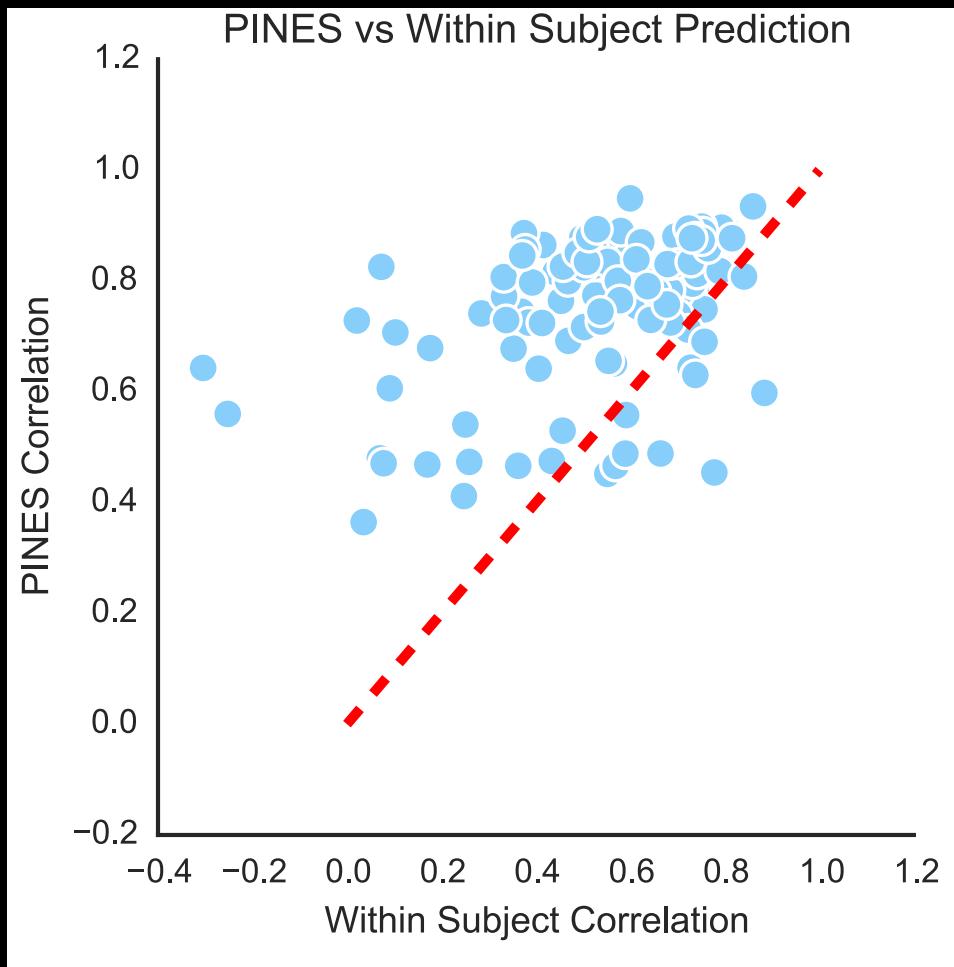
Opinion: Skip the searchlight

- Very computationally **expensive**
- Need to correct for **multiple comparisons**
- Only controls for activity in **local** regions
- Can't actually **compare** regions (where is information encoded)
- Can't **integrate** searchlights
- Most people don't even save the model weights
- Use **parcellations** or ROIs instead

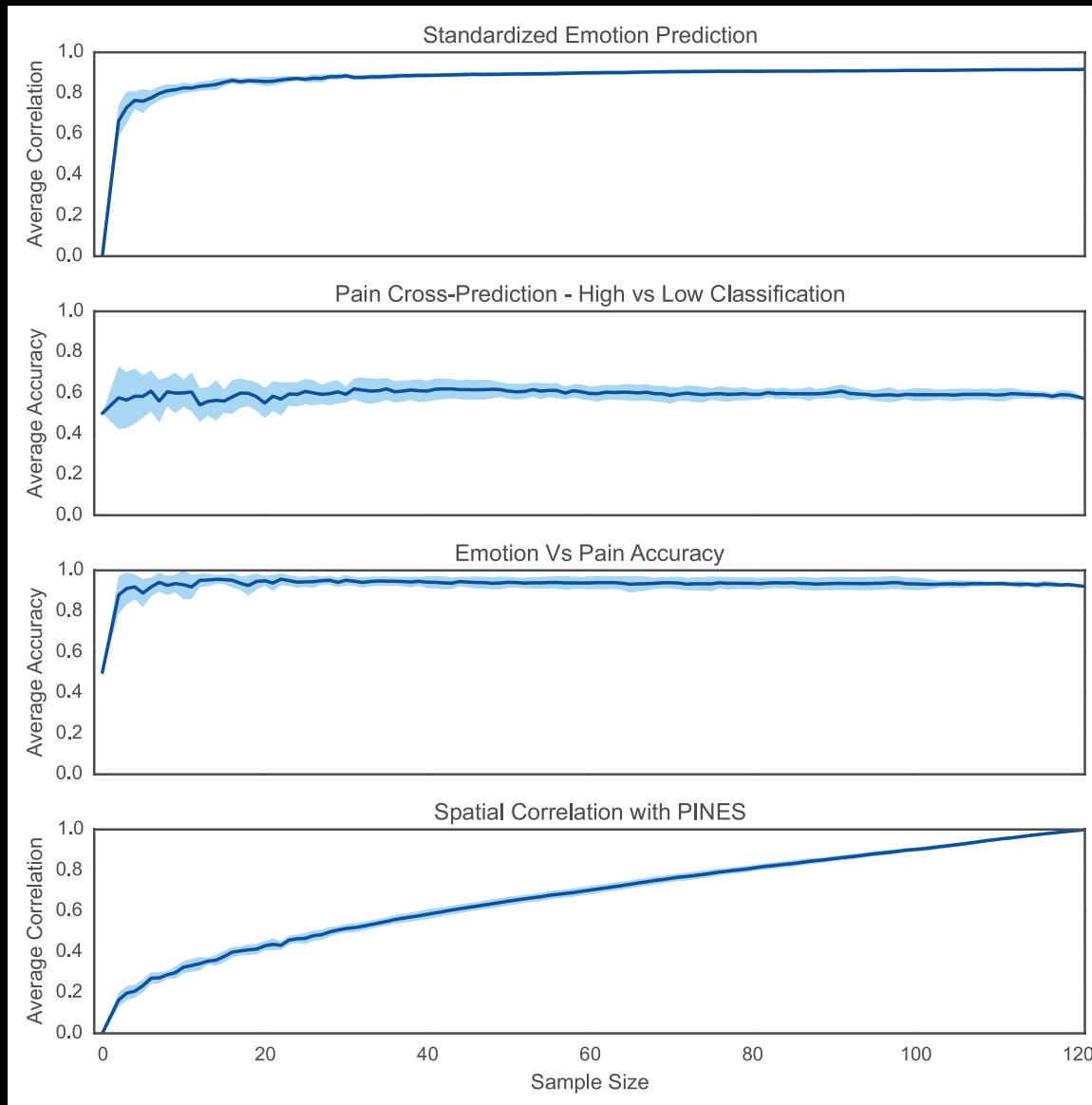
Hackathon Ideas: Other features?

- Pairwise connectivity (Yoni)
- Alternative HRF convolutions (e.g., width instead of height) (Aaron)
- Spatial Frequency (Feilong, Vincent, Steve)

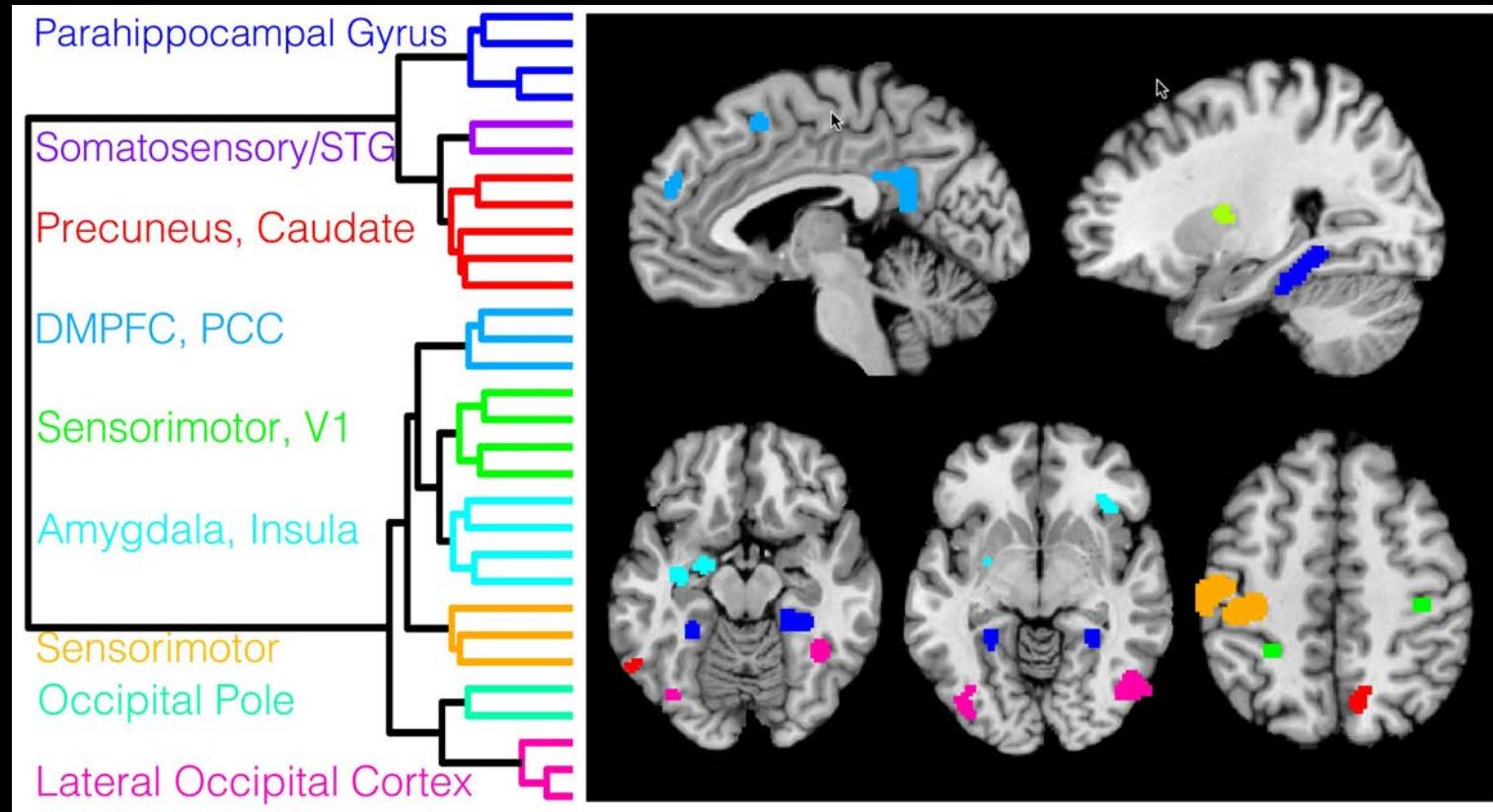
PINES outperforms individual subject models



Training Size

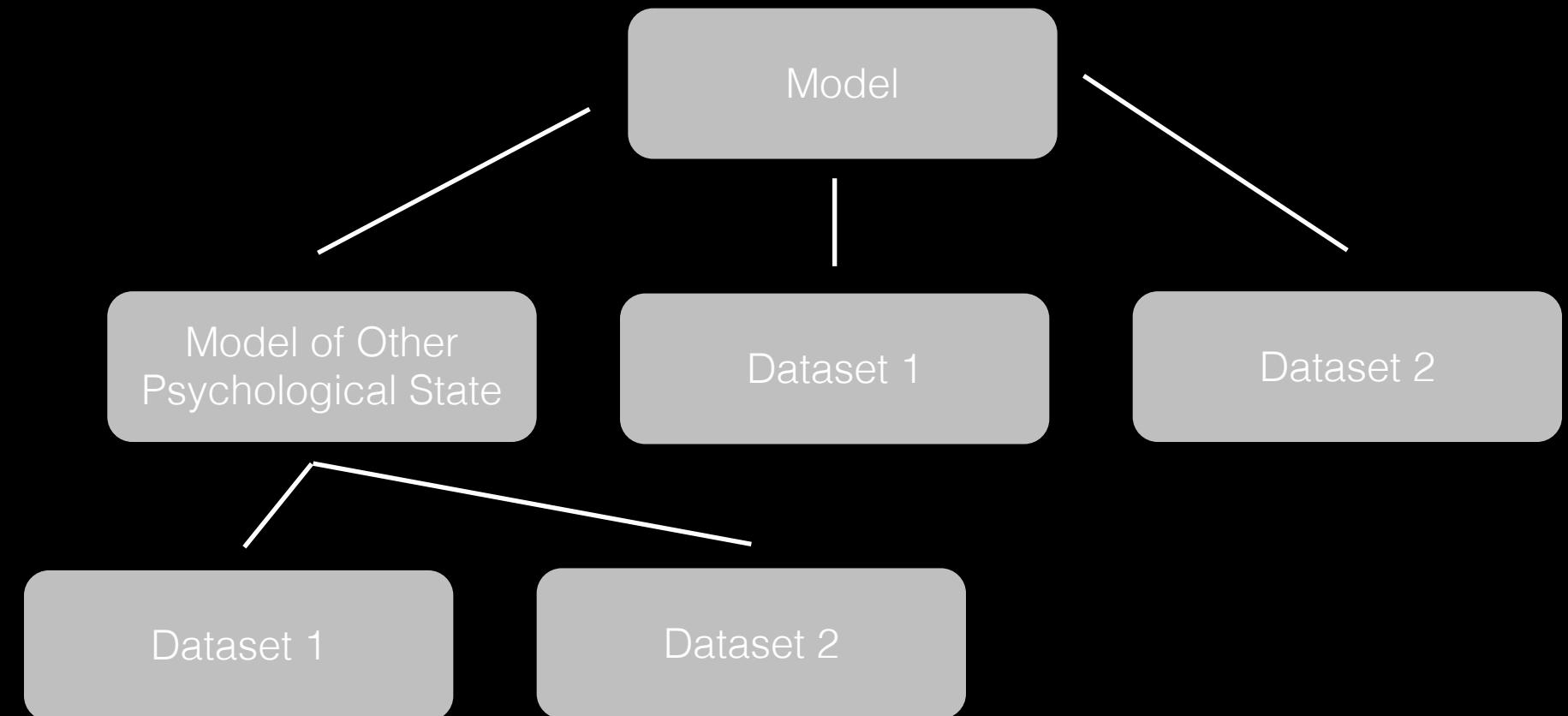


PINES is comprised of multiple functional networks



Construct Validation

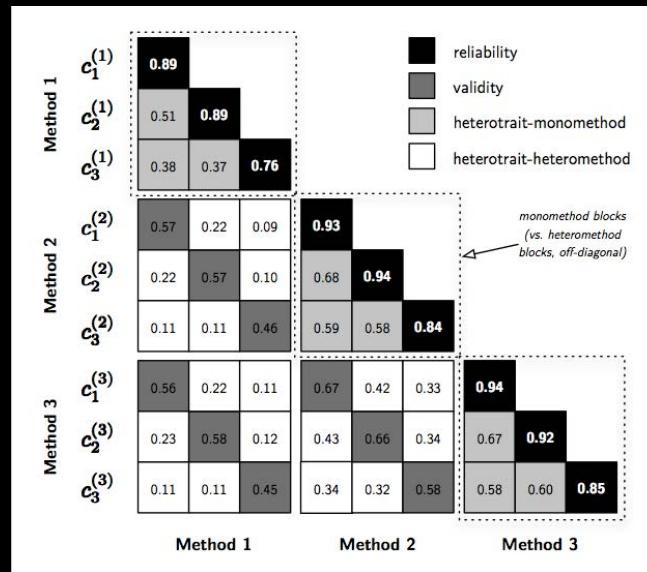
“A construct is defined implicitly by a network of associations or propositions in which it occurs. Constructs employed at different stages of research vary in definiteness.”



Multitrait Multimethod Matrix

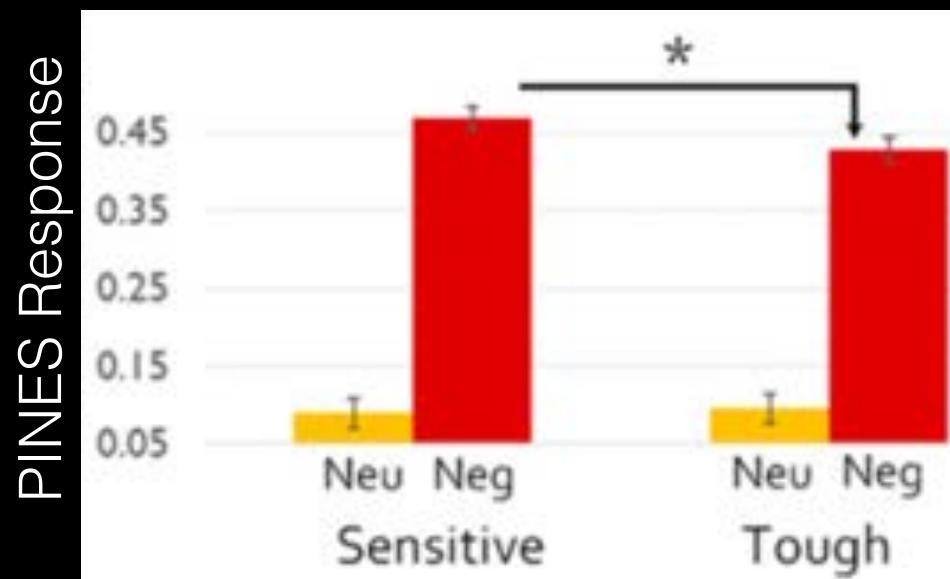
1. Validation requires **convergence** using independent measurement procedures.
2. Validation must also **discriminate** non-related constructs
3. There is **error** in the construct and its measurement

"more than one trait as well as more than one method must be employed in the validation process."



PINES generalizes to new scanner, lab, and task

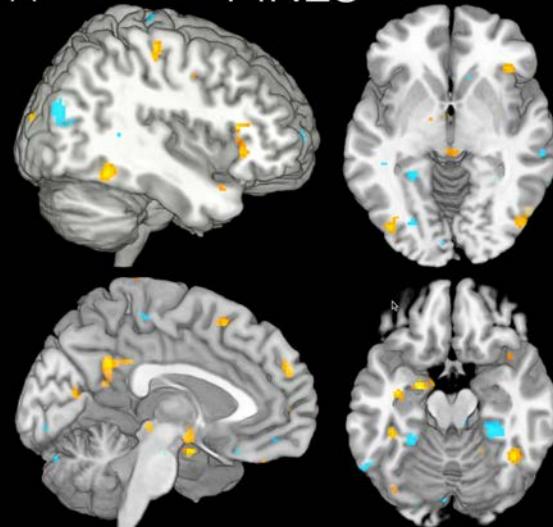
PINES Response to Emotion Distancing



PINES is Specific to Emotion

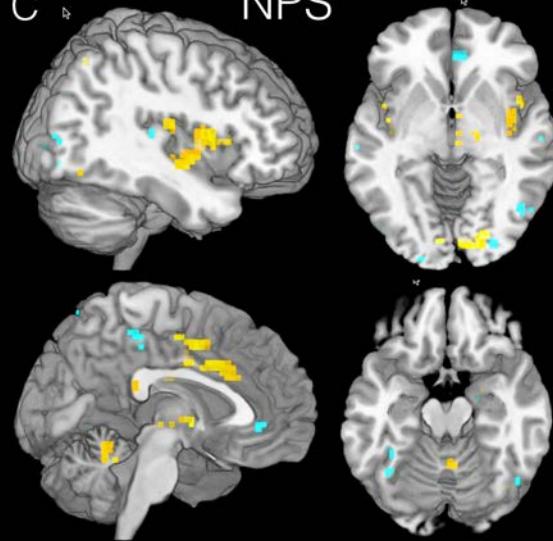
A

PINES

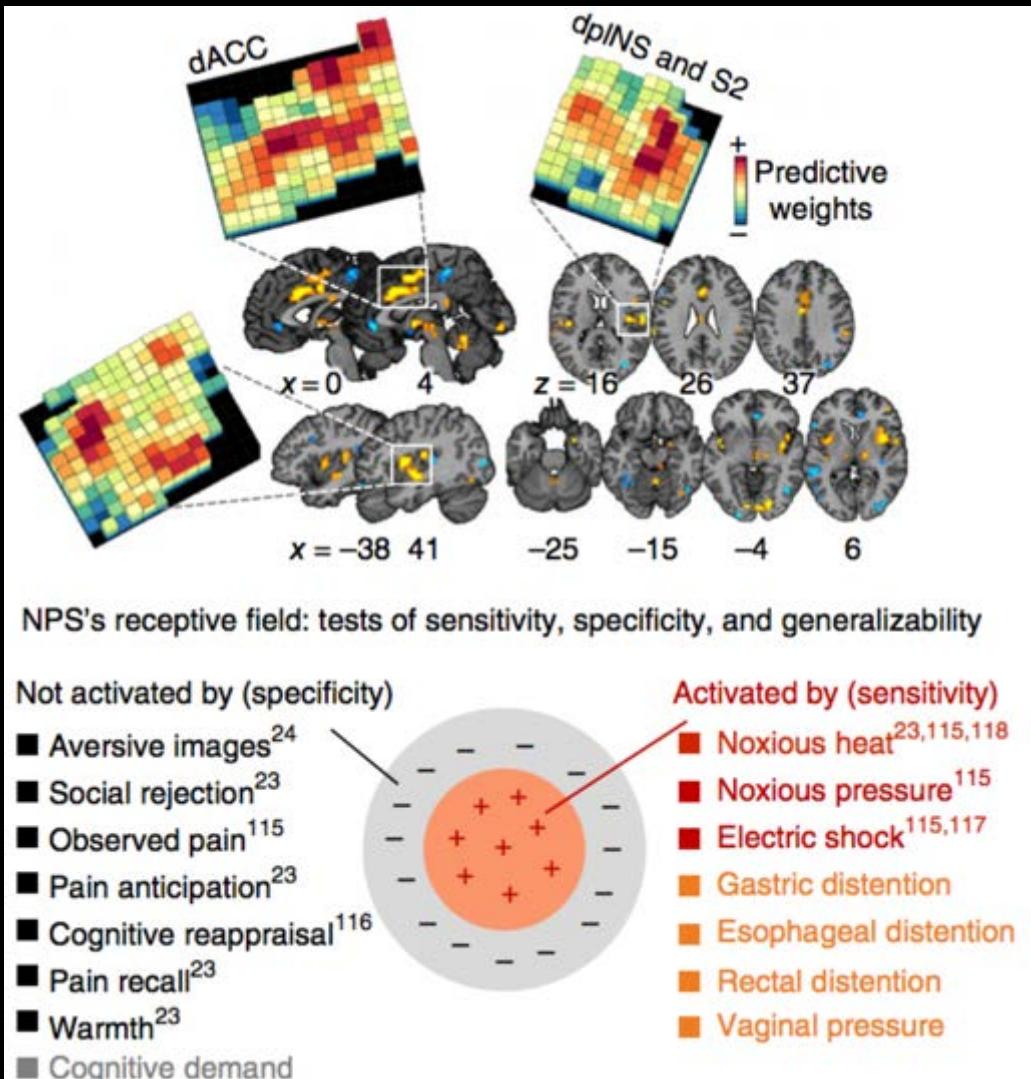


C

NPS



Assessing sensitivity & specificity requires cross-lab collaborations



Neurolearn

A web platform for analyzing neuroimaging data stored in NeuroVault
using machine-learning tools.

[SIGN IN TO START](#)

Search & select neuroimaging data

Search NeuroVault collections and
select images.

How it works

The screenshot shows the Neurolearn interface with a blue header and a white main area. At the top, there's a navigation bar with 'Neurolearn beta', 'Dashboard', 'Explore', 'FAQ', and a sign-in button. Below the header, a large button says 'SIGN IN TO START'. The main content area has a title 'How it works' and a section titled 'Search & select neuroimaging data'. A sub-section titled 'Input Data' is shown, with a sub-sub-section 'Search & select neuroimaging data'. It includes a search bar with 'Single Subject', a dropdown menu 'Sort: Recently updated', and a 'Selected Images' panel showing 'Single Subject Thermal Pain (84)'. At the bottom right is a green 'Send feedback' button.

Chang, Burnashev, & Wager (In Prep)

<input type="checkbox"/> Name	Status	Algorithm	Cross-validation Type	Training Duration	Created
Pain - RidgeCV	Complete	Ridge CV	kfolds	93 sec	5 months ago
Predict Emotion Ratings from IAPS (SVR)	Complete	SVR	kfolds	95 sec	9 months ago
Predict IAPS Ratings (SVR)	In Progress...	SVR	loso		9 months ago
Predict IAPS Ratings	Complete	Ridge	kfolds	93 sec	9 months ago
pain test	Complete	Ridge	kfolds	24 sec	10 months ago
Train Model Demo - Ridge	Complete	Ridge	kfolds	29 sec	10 months ago
Predict Image Brightness	Complete	Ridge	kfolds	11 sec	a year ago
Pain Test	Complete	Ridge	kfolds	23 sec	a year ago
Luke Test Private	Complete	Ridge	kfolds	24 sec	a year ago
Pain H v L Ridge	Complete	Ridge Classifier	kfolds	21 sec	a year ago
Pain Ridge H v L	Complete	Ridge Classifier	kfolds	16 sec	a year ago
Pain High vs Low SVM	Complete	SVM	kfolds	20 sec	a year ago
test pain	Complete	Ridge	kfolds	19 sec	a year ago
test pain	Complete	Ridge		17 sec	a year ago
Pain (no resampling)	Complete	Ridge	kfolds	19 sec	a year ago
Thermal Pain Intensity Prediction	Complete	Ridge	kfolds	6 sec	a year ago

[Send feedback](#)

0 6573 Forum 2.1 Connections Sort: Frequency Updated Images (545) Training Label

Has DOI (3)
 Has Image Map (21)

Image Map Types
 ROI/mask (1)
 T map (1)
 Z map (13)
 other (2)
 parcellation (1)
 univariate-beta (4)

Image Types
 statistic_map

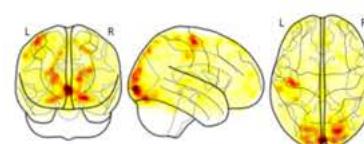
Image Modalities
 Other (2)
 fMRI-BOLD (1)

Image Analysis
 meta-analysis
 single-subject

Select Images

Train

Name	Image Type	Map Type
<input checked="" type="checkbox"/> IAPS_Subject_102_Rating_1_Train.nii.gz	statistic_map	univariate-beta map
<input checked="" type="checkbox"/> IAPS_Subject_102_Rating_2_Train.nii.gz	statistic_map	univariate-beta map
<input checked="" type="checkbox"/> IAPS_Subject_102_Rating_3_Train.nii.gz	statistic_map	univariate-beta map
<input checked="" type="checkbox"/> IAPS_Subject_102_Rating_4_Train.nii.gz	statistic_map	univariate-beta map
<input checked="" type="checkbox"/> IAPS_Subject_102_Rating_5_Train.nii.gz	statistic_map	univariate-beta



NeuroVault 4 images

Send feedback

1. Input Data

2. Training Label

3. Model Preferences

Training Label

Analysis type

- Regression Classification

Select the row with the variable you would like to use for training labels

Target	Name	Data Type	Sample Field Values	Edit	Delete
<input type="radio"/>	Files	Categorical	IAPS_Subject_102_Rating_1_Train.nii.gz, IAPS_Subject_102_Rating_2_Train.nii.gz, IAPS_Subject_102_Rating_3_Train.nii.gz	 Edit	 Delete
<input type="radio"/>	Rating	Number	1, 2, 3	 Edit	 Delete
<input type="radio"/>	AGE	Number	30, 30, 30	 Edit	 Delete
<input type="radio"/>	YRS_SCH	Number	14, 14, 14	 Edit	 Delete
<input type="radio"/>	SubjectID	Number	102, 102, 102	 Edit	 Delete
<input type="radio"/>	SEX	Categorical	Female, Female, Female	 Edit	 Delete
<input type="radio"/>	RACE	Categorical	White, White, White	 Edit	 Delete

[Add new field...](#)[Continue to Model Preferences](#)[Send feedback](#)

1. Input Data

2. Training Label

3. Model Preferences

Model Preferences

Model Name

Emotion Prediction

Description (optional)**Mask (optional)**

NeuroVault Image Id

Access level

- Public (anyone can see this model)
- Private

Algorithm

- SVR
- Linear Regression
- Lasso
- Lasso CV
- Ridge
- Ridge CV

 Send feedback**Model Type**

ALGORITHM
Ridge CV 

TRAINING LABEL
Rating

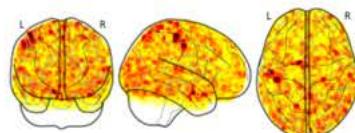
TRAINING DATASET
545 images

Model Training Data

Recent Model Tests

A large-scale gradient describing the topographical organisation of multi-dimensional memory representations in the human cortex
12 images • 0 mean r

Weightmap



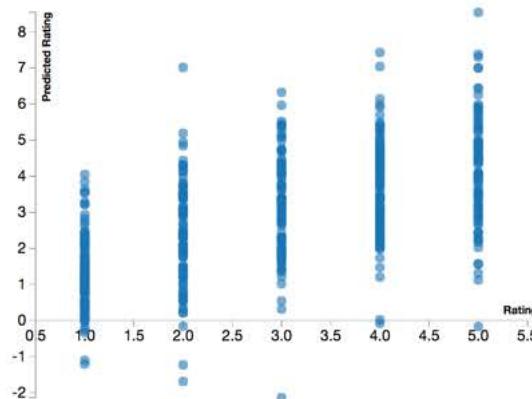
[Open Interactive Viewer](#)

[!\[\]\(553fc0557dc55ddc76815ec83dfa644a_img.jpg\) Download NIFTI file](#)

Cross Validation

Method	Root Mean Squared Error	Correlation	CV Root Mean Squared Error	CV Correlation
kfolds	0.00	1.00	1.37	0.61

Actual vs. Predicted



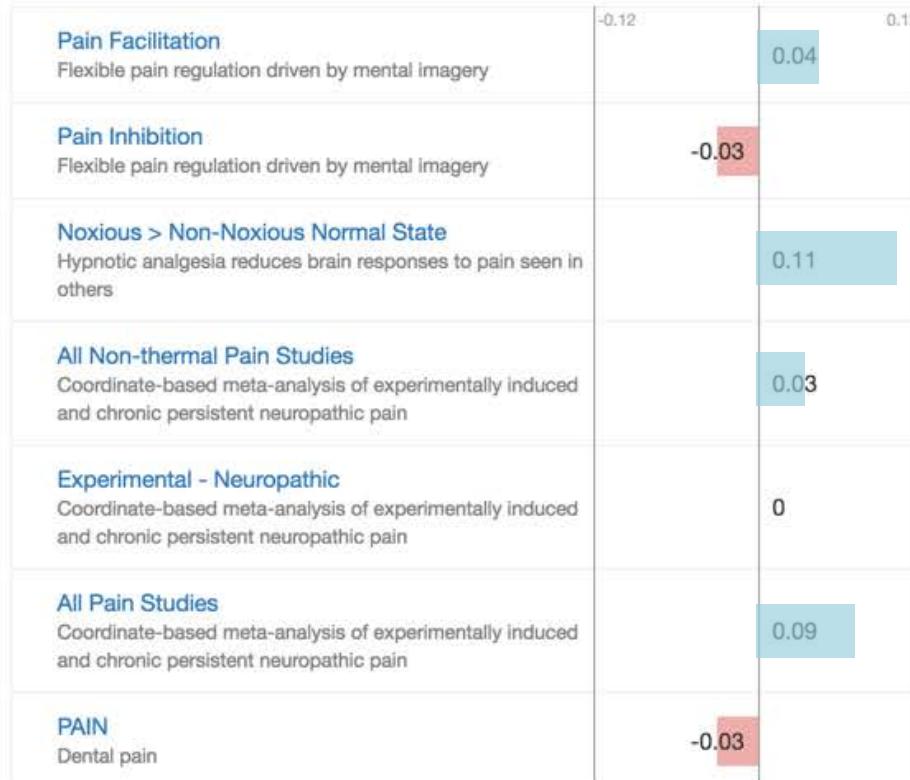
 [Send feedback](#)

Test Models

Images

Filter Images

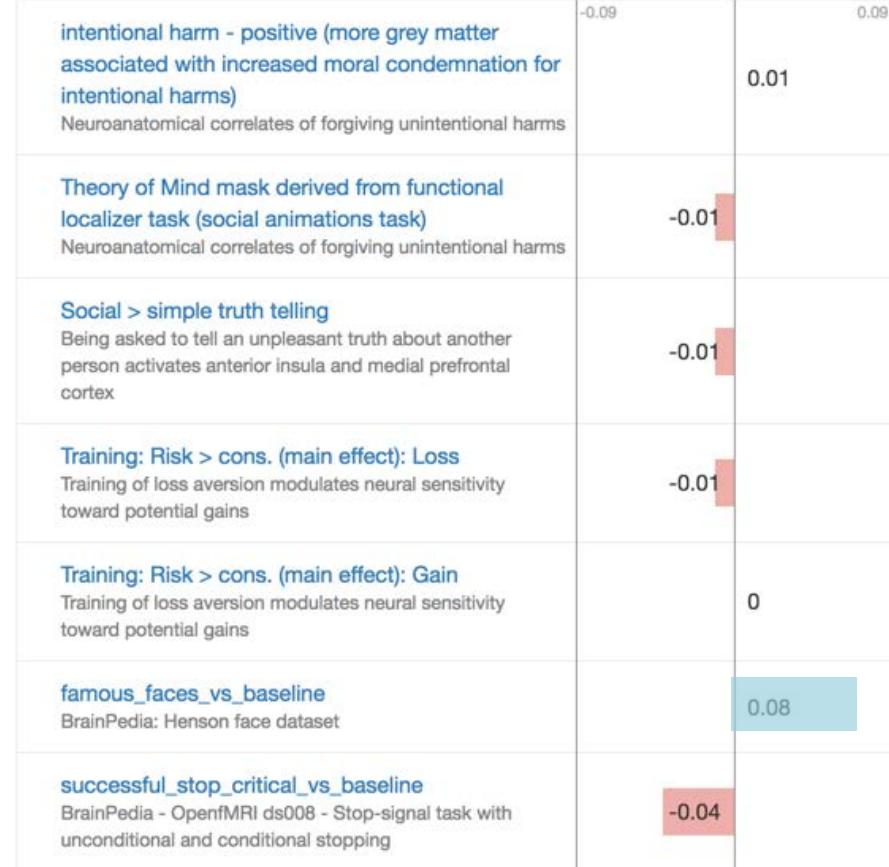
7 images



Images

Filter Images

7 images



How do we represent other's experiences?



Opposing views on mental representations

Simulation Theory (mirror neuron, embodied emotions, shared affect)

"The discovery of mirror neurons in the frontal lobes of monkeys, and their potential relevance to human brain evolution ... is the single most important "unreported" ... story of the decade. I predict that mirror neurons will do for psychology what DNA did for biology: they will provide a unifying framework and help explain a host of mental abilities that have hitherto remained mysterious and inaccessible to experiments."

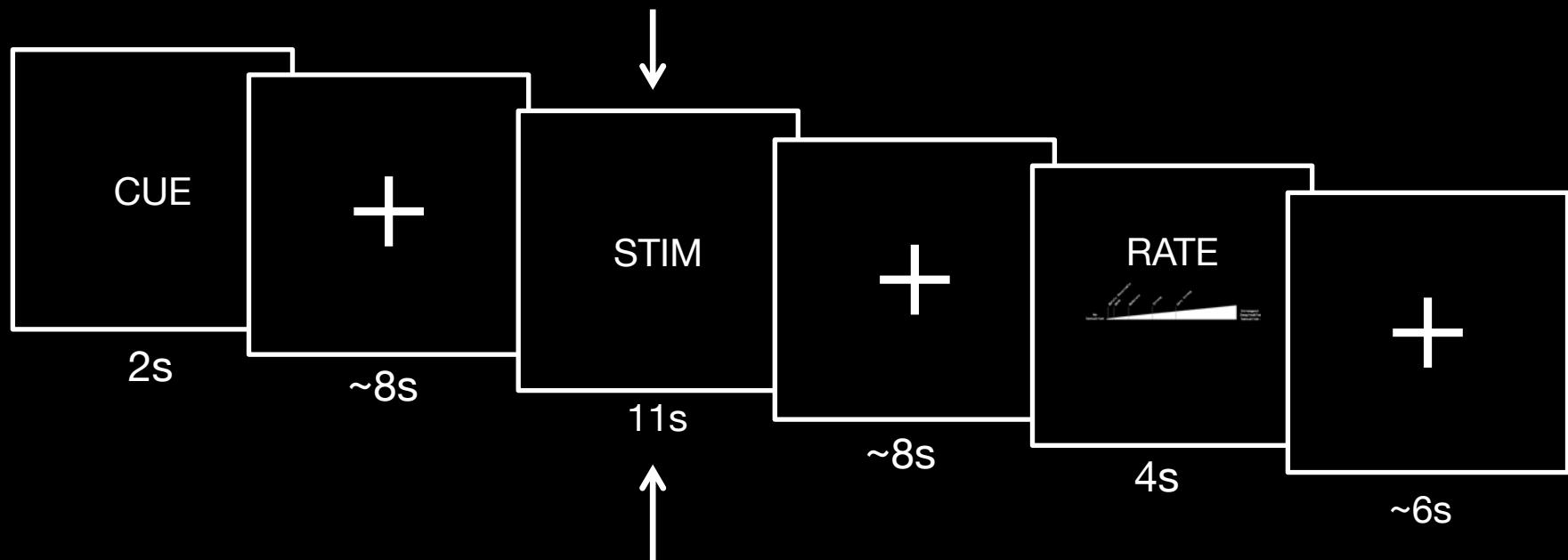
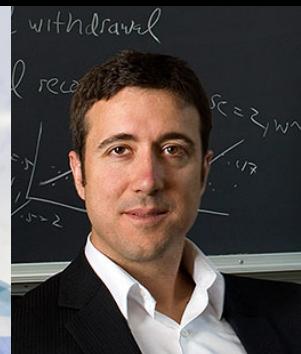
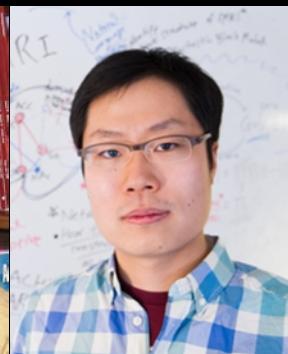
V.S. Ramachandran (2000)

Theory-Theory (mentalizing, perspective-taking, cognitive)

"Though our brother is upon the rack, as long as we ourselves are at our ease, our senses will never inform us of what he suffers. ... it is by the imagination only that we can form any conception of what are his sensations."

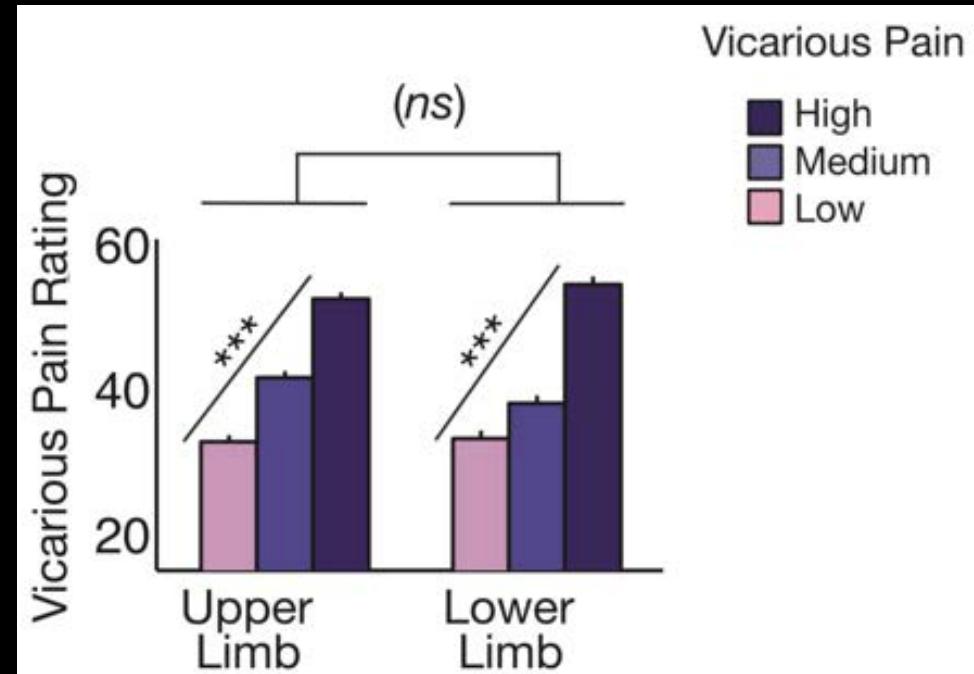
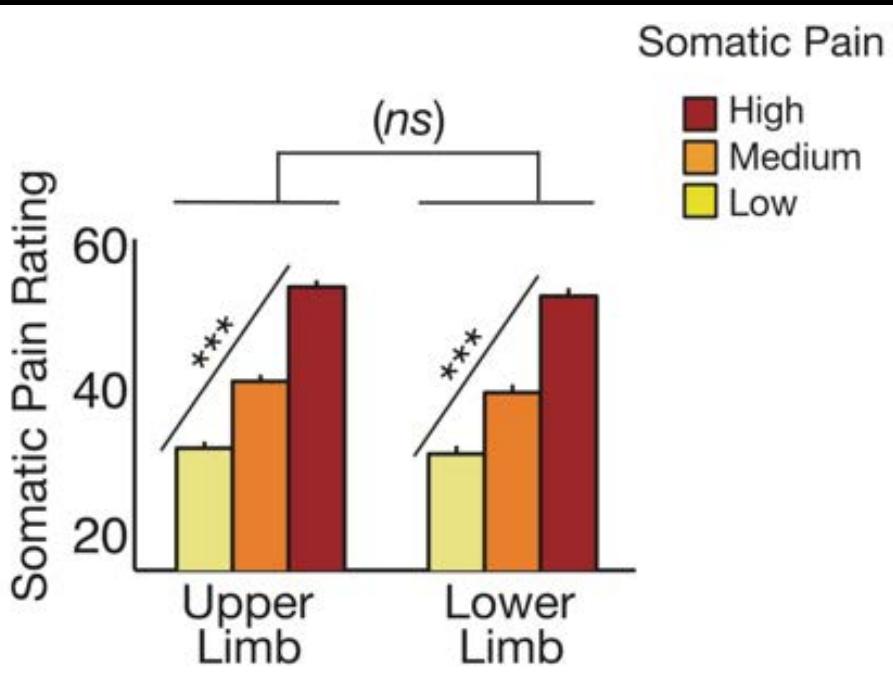
Adam Smith (1759)

Somatic Pain

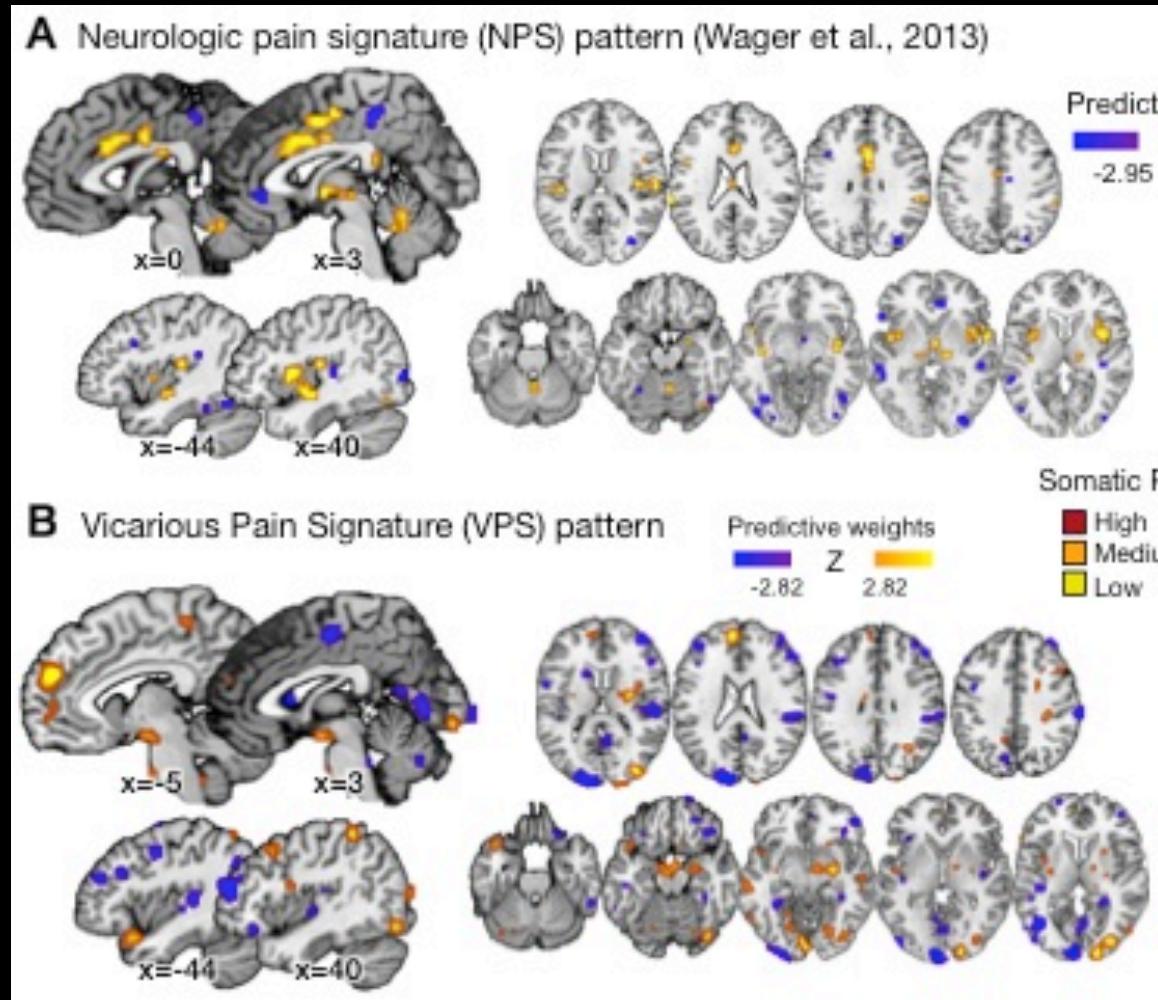


Vicarious Pain

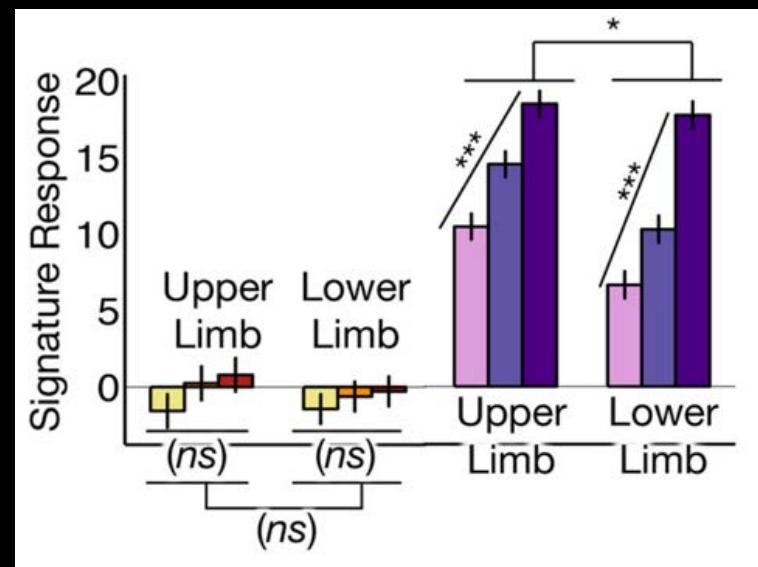
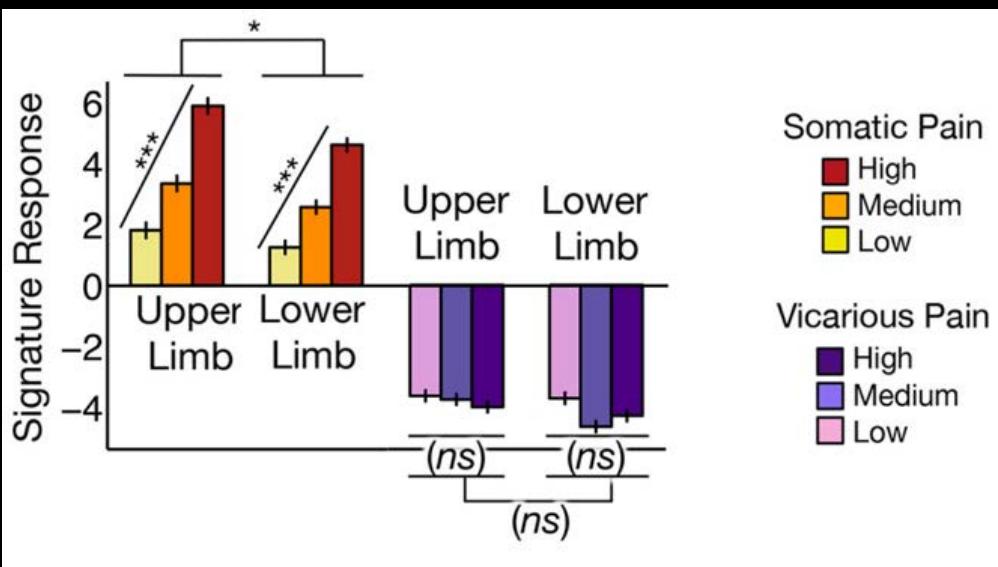
Krishnan, Woo, Chang, et al. (2016) eLife



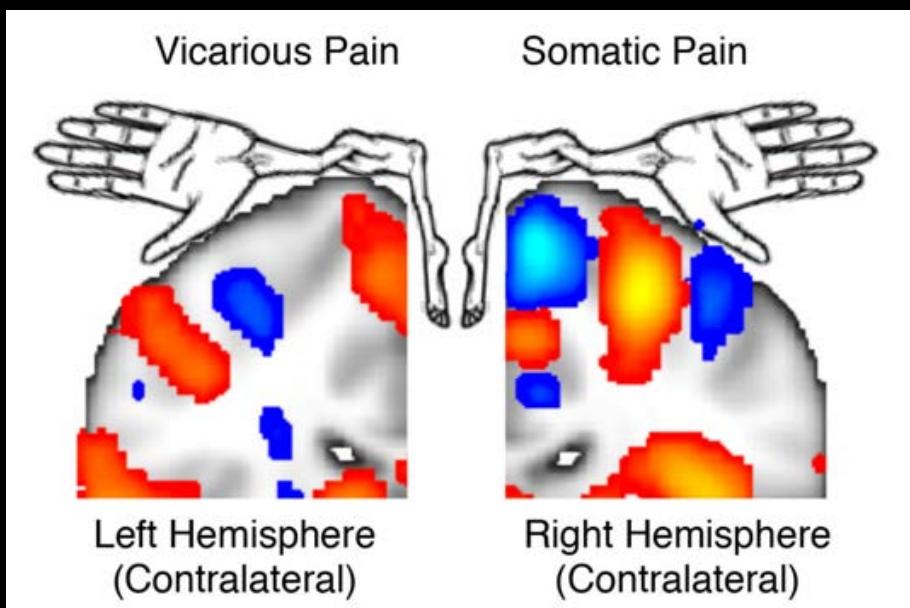
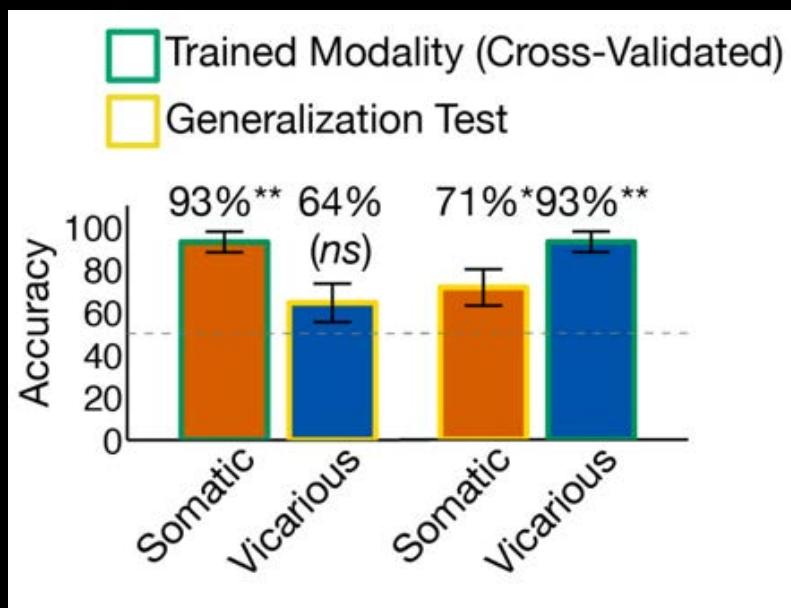
Somatic & vicarious pain are encoded in dissociable systems



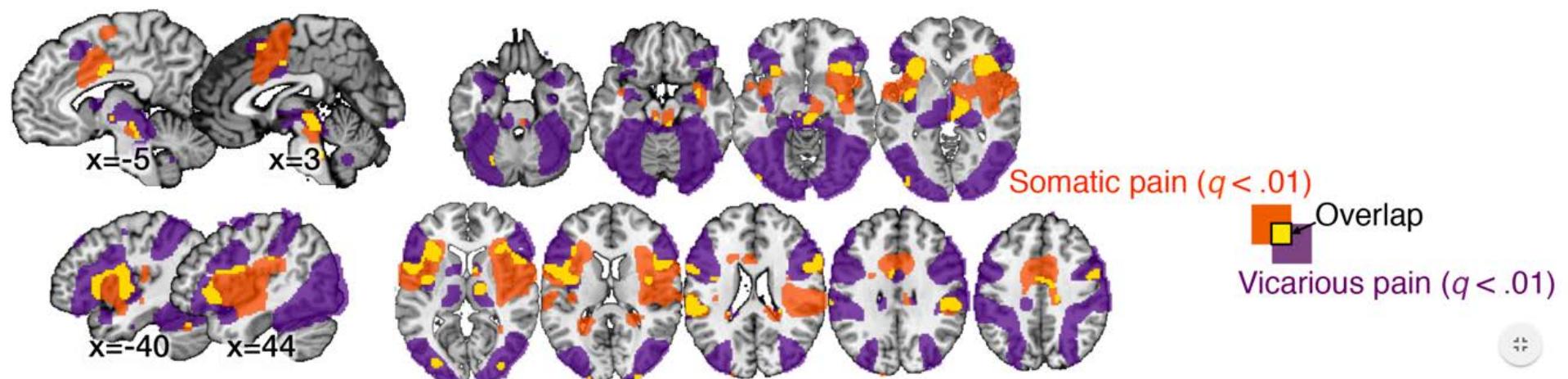
Separate Modifiability



No sensorimotor somatopy for vicarious pain

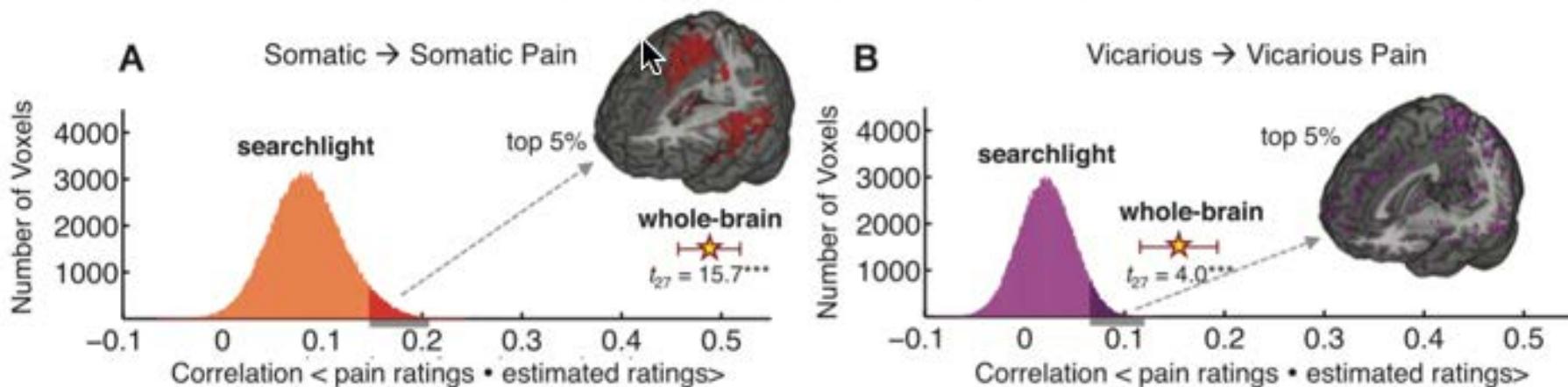


Overlap in univariate analyses

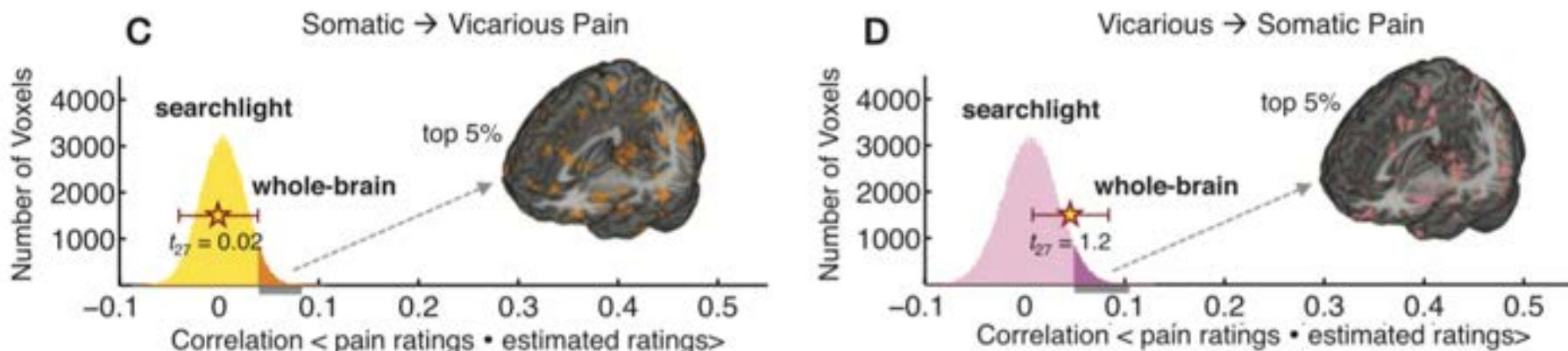


Vicarious Pain Searchlight Analysis

Within-Modality Prediction Results

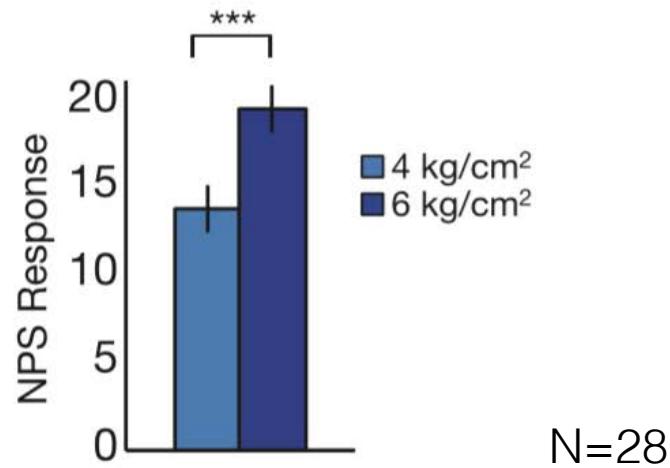


Cross-Modality Prediction Results

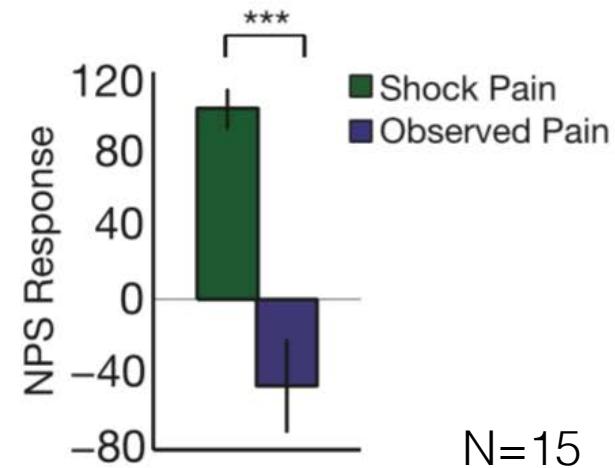


Generalizability to Other Labs & Paradigms

A Study 2: NPS Response for Mechanical Pain



B Study 3: NPS & VPS Responses for Electrodermal (Shock) Pain & Observed Pain





Lab Members

Seth Frey – Postdoc

Andy Chen – Postdoc

Eshin Jolly – Grad Student

Jin Cheong – Grad Student

Emma Templeton – Grad Student

Kristina Rapuano – Grad Student

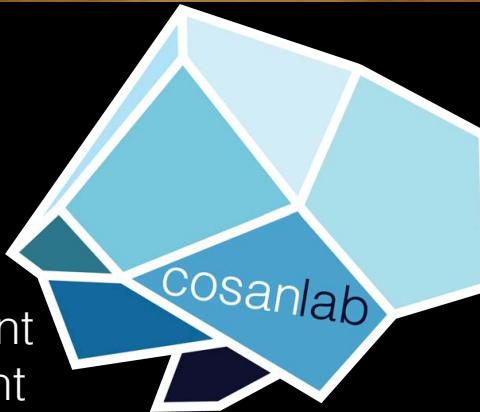
Daisy Burr – Grad Student

Alex DaSilva – Grad Student

Jeroen van Baar – Visiting Student

Courtney Rogers – Lab Manager

Anton Burnashev - Developer



Research Assistants

Eric Andrews

Zainab Molani

Sam Greydanus

Aimee Sung

Hirsh Elhence

Zohra Aslami

Sawyer Brooks

Dawit Workie

Sushmita Sadhukha

Arati Gangadharan

neukom.

<https://github.com/ljchang/nltools>