

Recent and upcoming developments

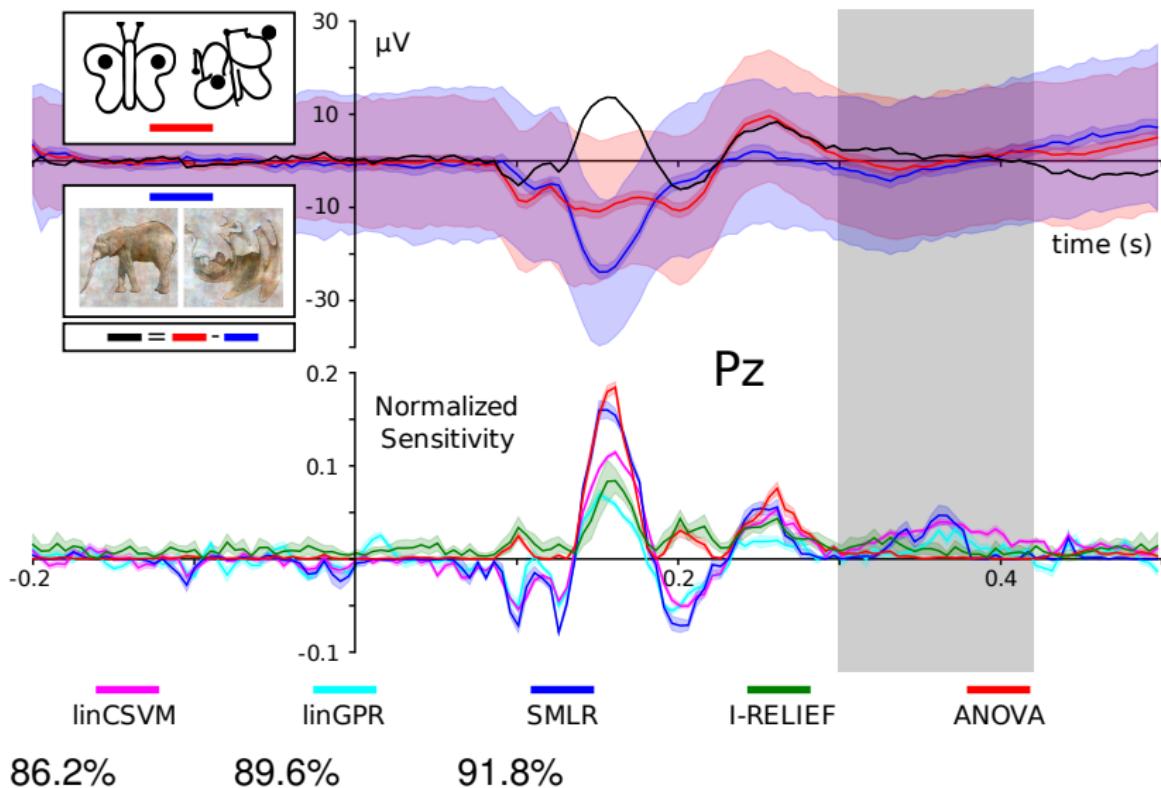
Michael Hanke & Yaroslav Halchenko

University of Magdeburg, Germany
Dartmouth College, USA

Giessen 2014

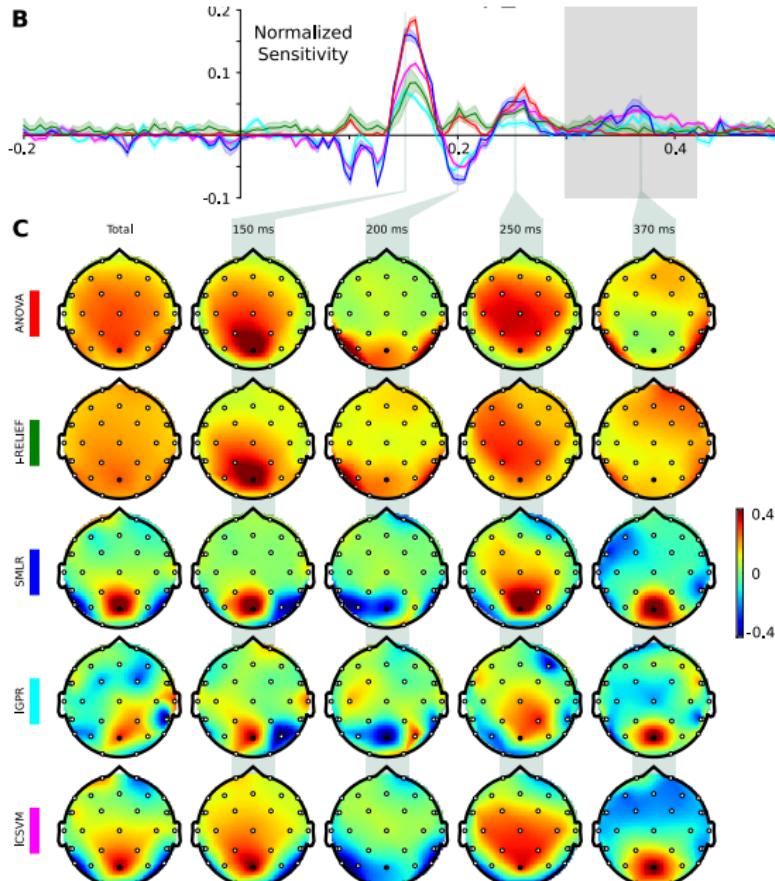
Modality agnostic sensitivity analysis

Modality-independent: EEG

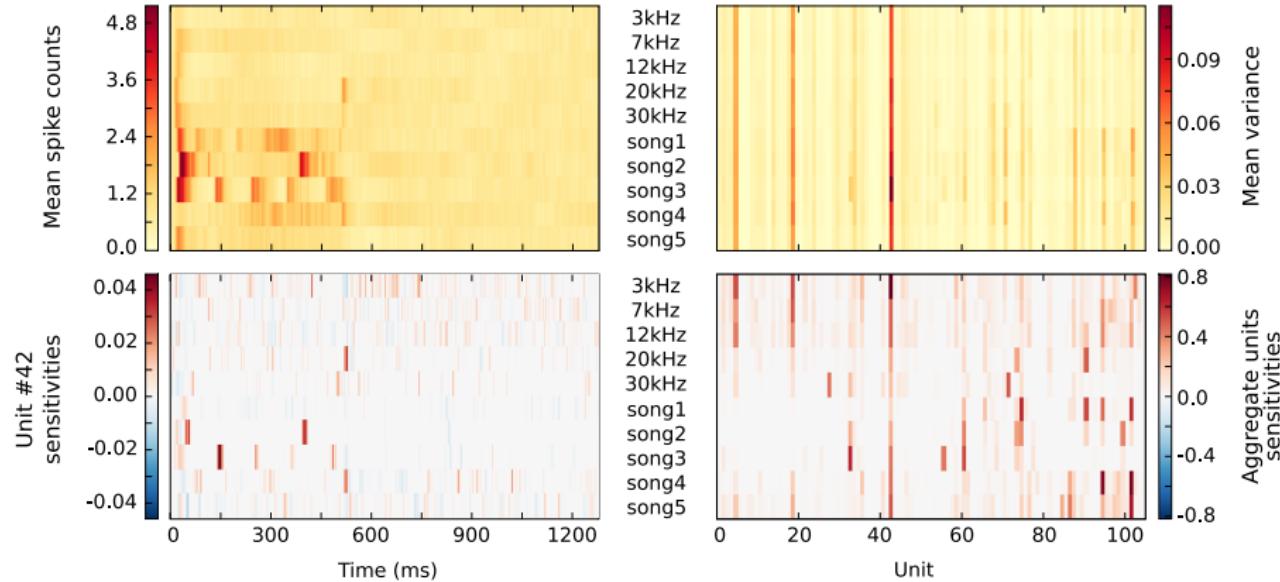


Hanke et al. (2009) (Daten: Fründ et al., 2008)

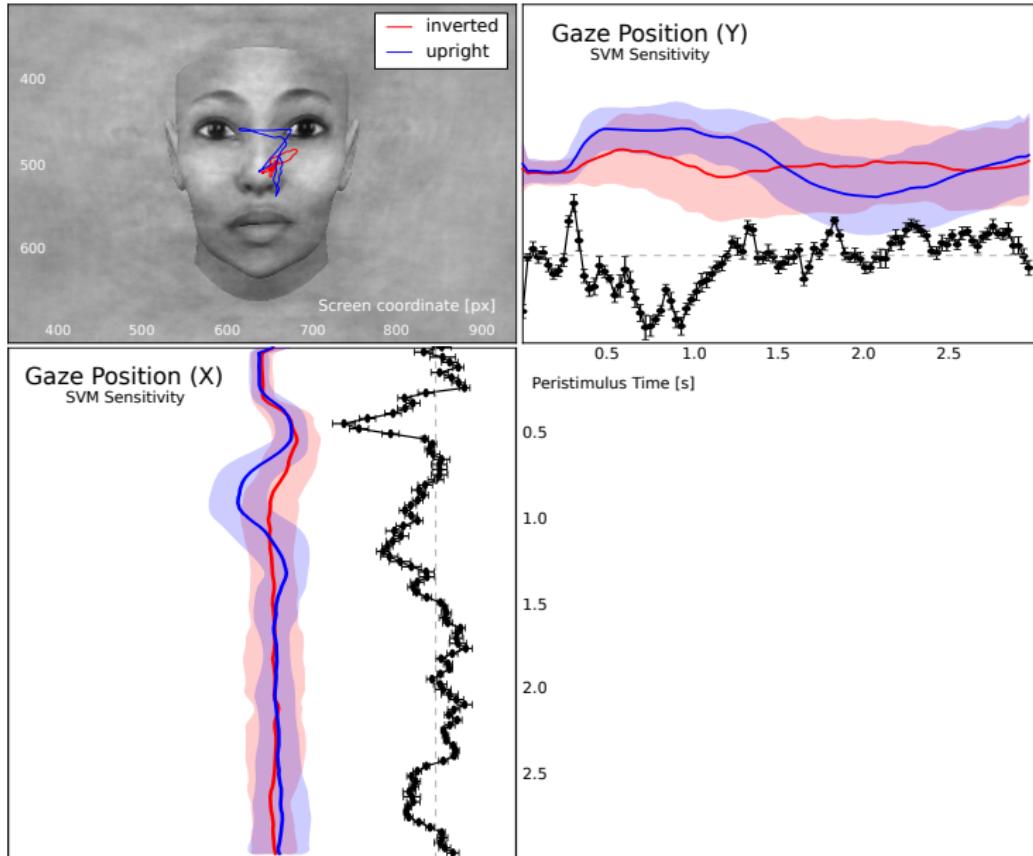
Modality-independent: EEG Temporal Profile



Modality-independent: Spikes



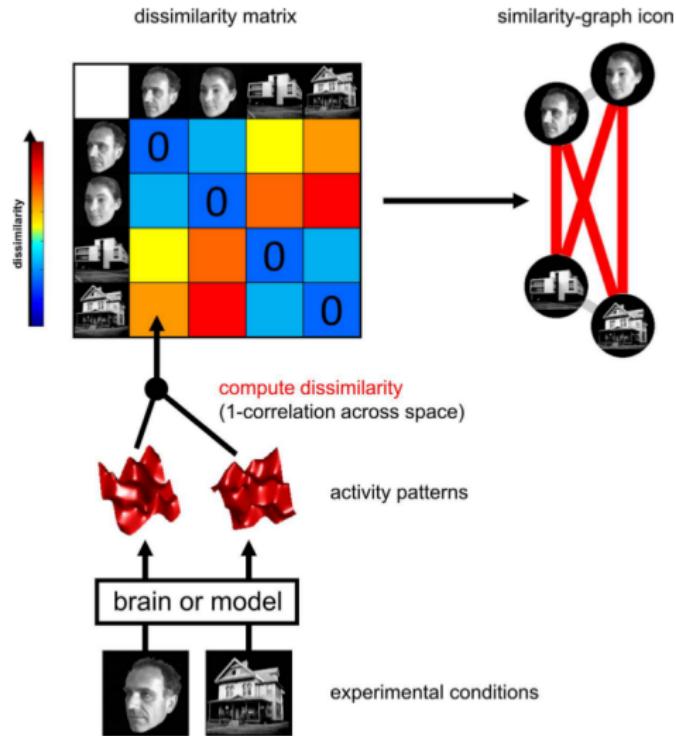
Modality-independent: Eye movements



Similarity structure analysis

2nd-order isomorphism

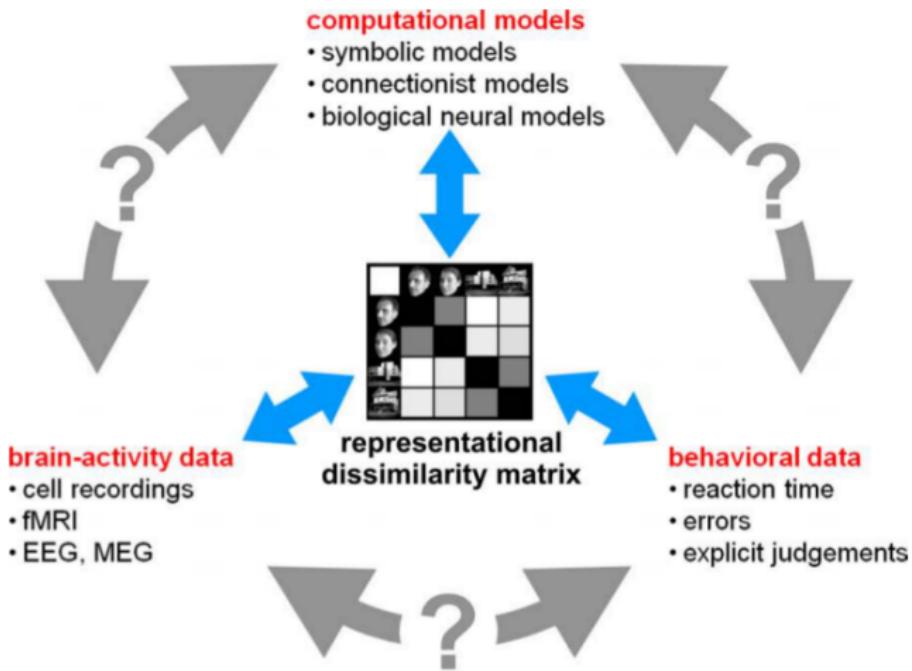
similarity of similarity structure



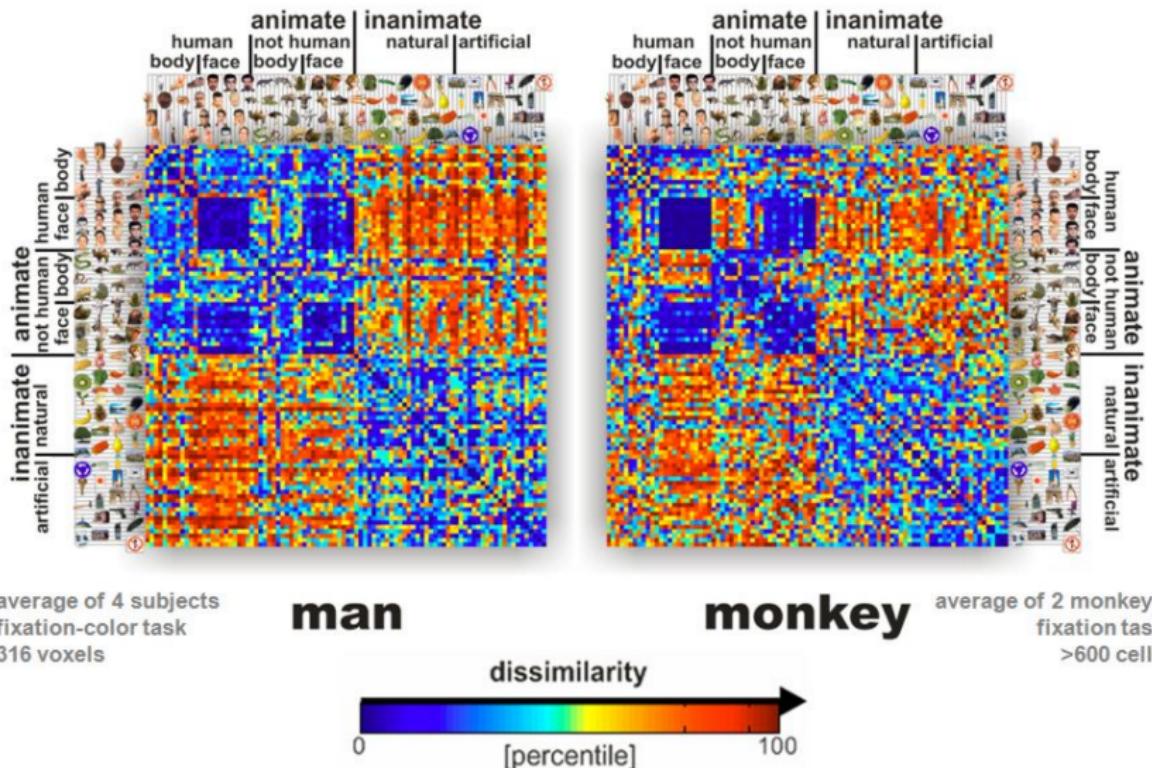
Kriegeskorte et al., Frontiers in Systems Neuroscience, 2008

2nd-order isomorphism

similarity of similarity structure

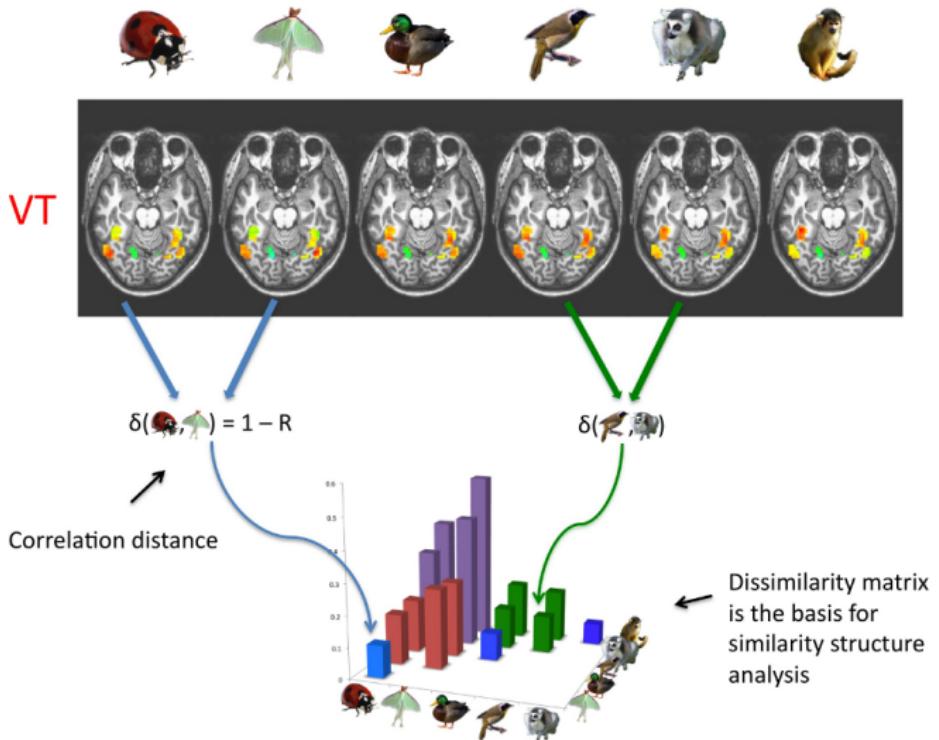


Representational spaces across species



Kriegeskorte et al., COSYNE, 2008

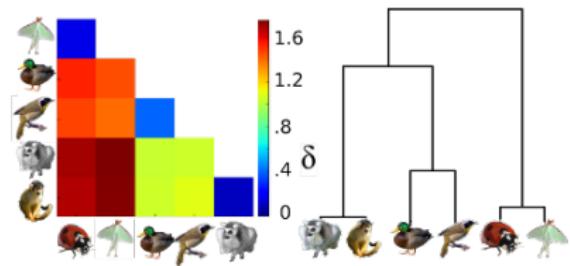
Similarity Analyses



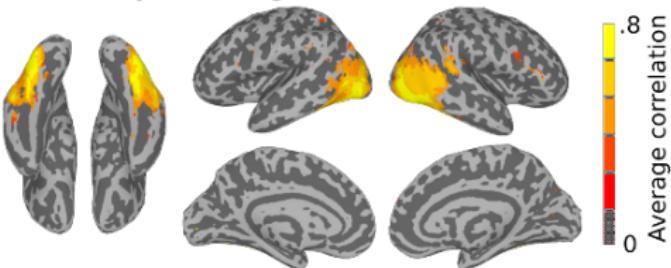
Connolly et al. (2012)

Similarity Analyses: V1 vs behavioral models

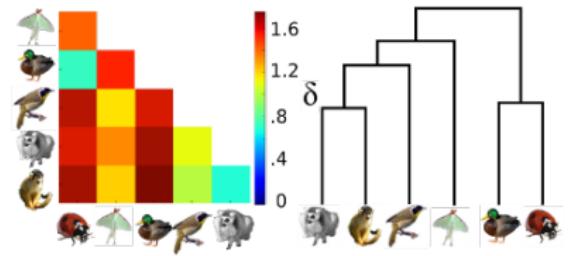
A. Behavioral ratings DM



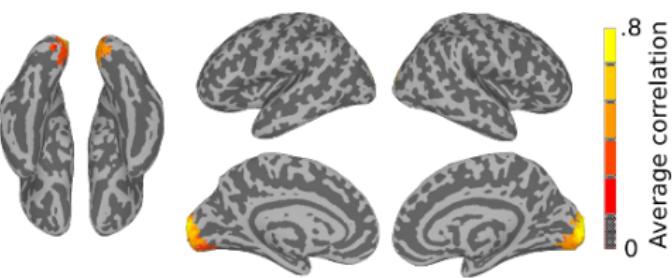
B. Similarity searchlight: Behavioral DM



C. V1 model DM

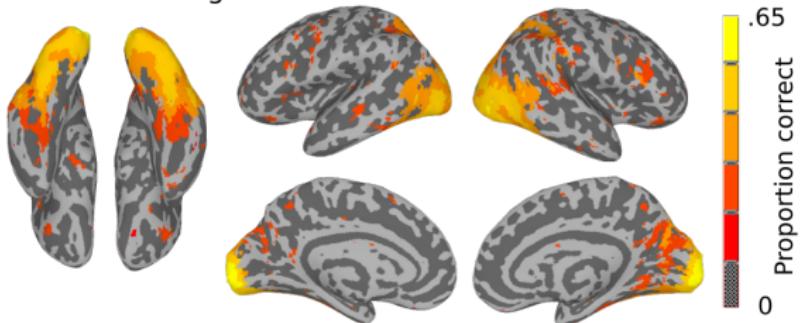


D. Similarity searchlight: V1 model DM

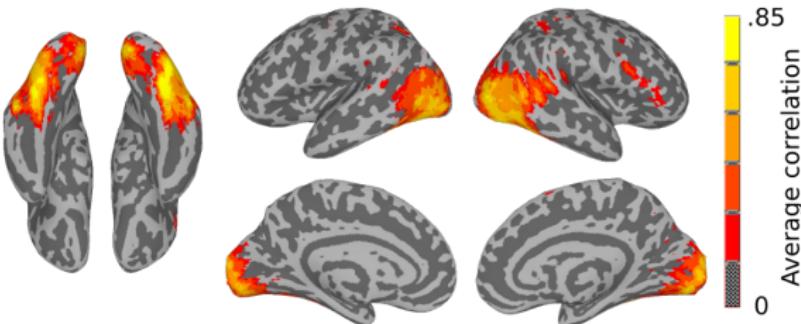


Similarity Analyses: Cross-subject agreement

A. SVM searchlight



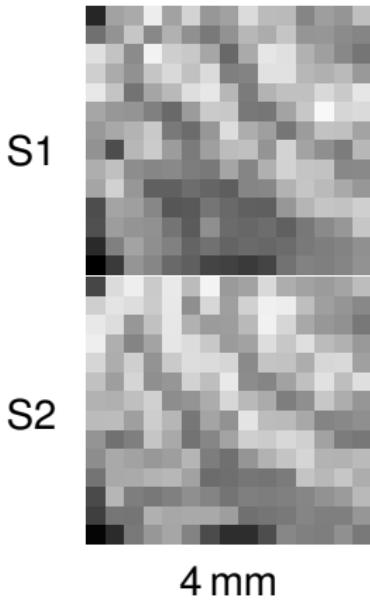
B. Cross-subject similarity correlation searchlight



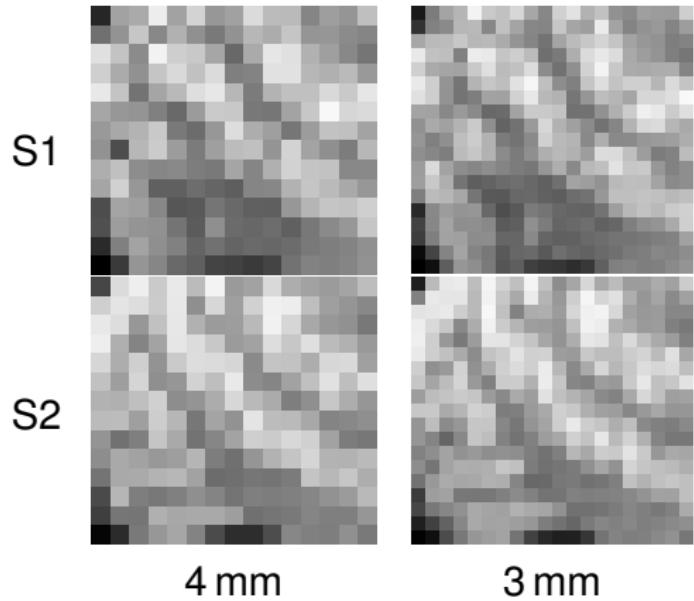
Similarity structure analysis works
with **any kind of model** and
across data modalities

But if 2nd-order is not enough?

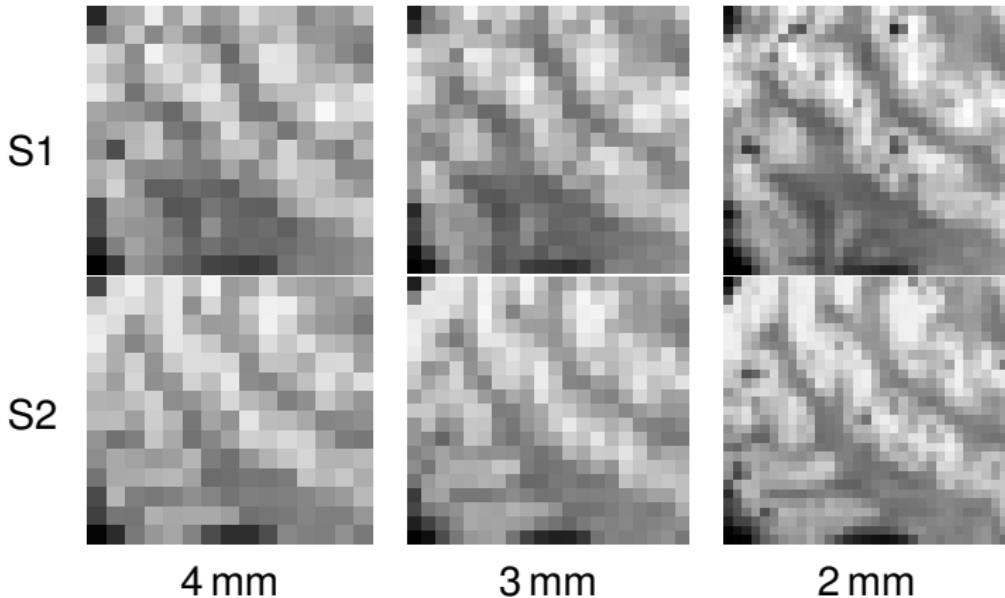
Localization – the end is near!



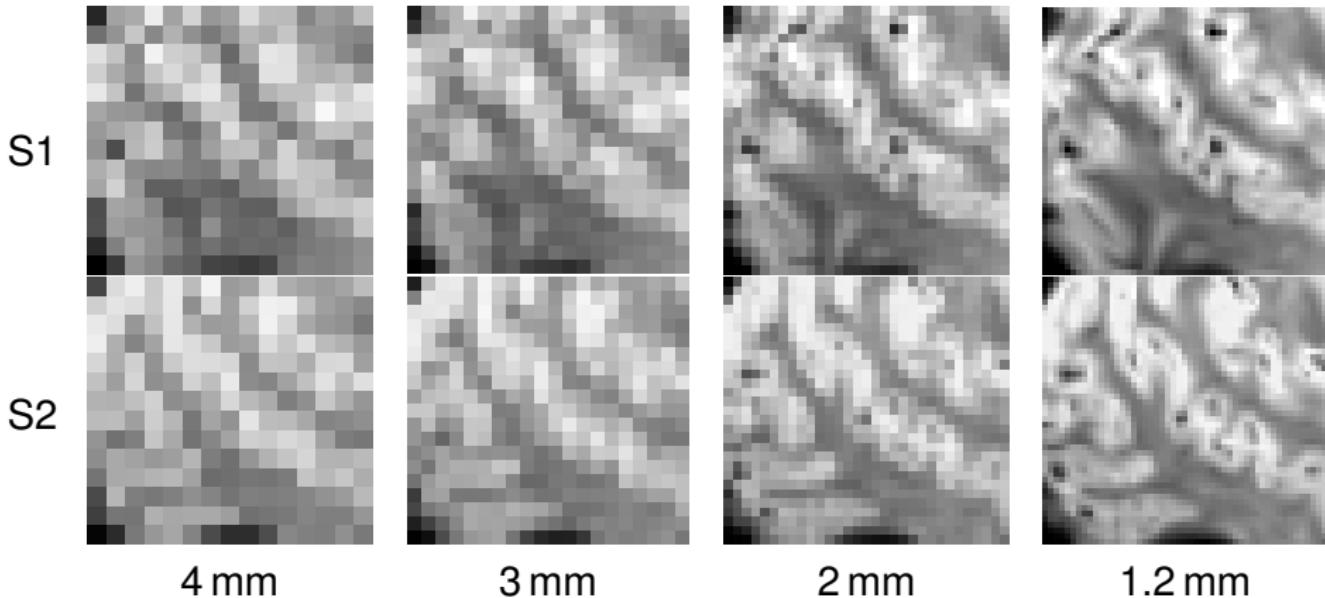
Localization – the end is near!



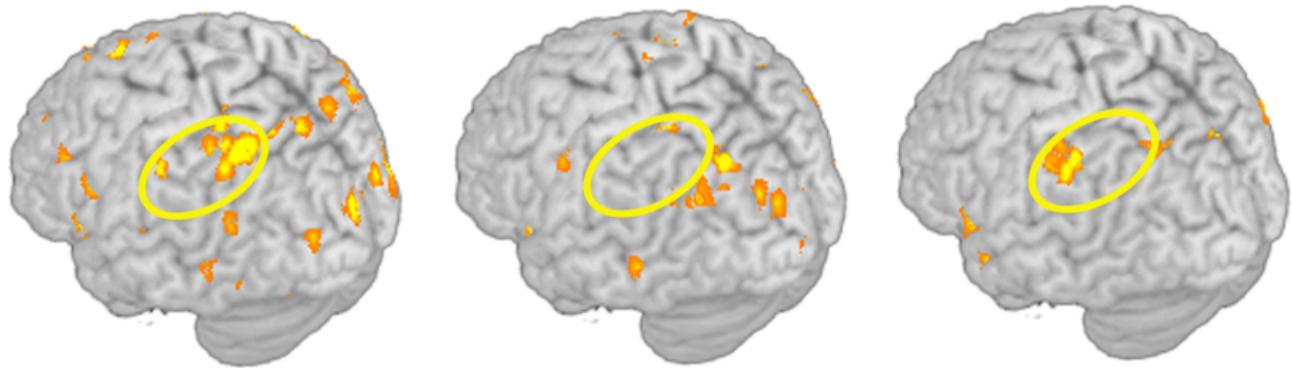
Localization – the end is near!



Localization – the end is near!

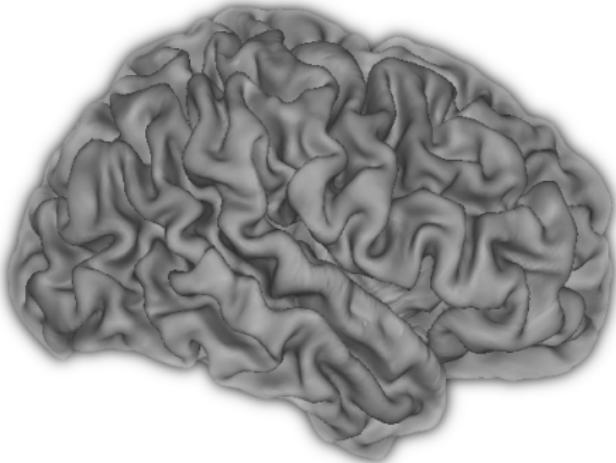
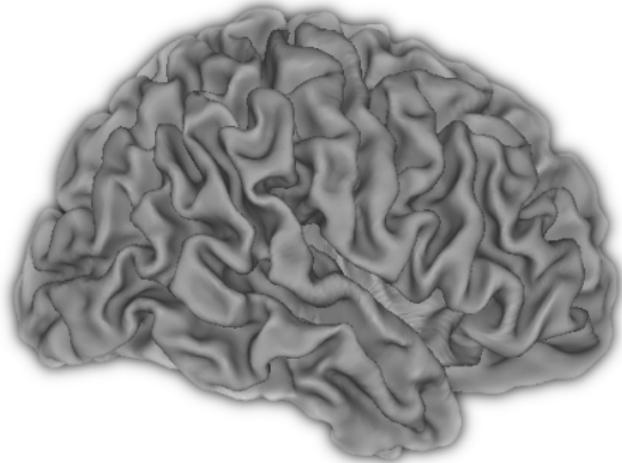


Challenge: Idiosyncratic brain activity patterns

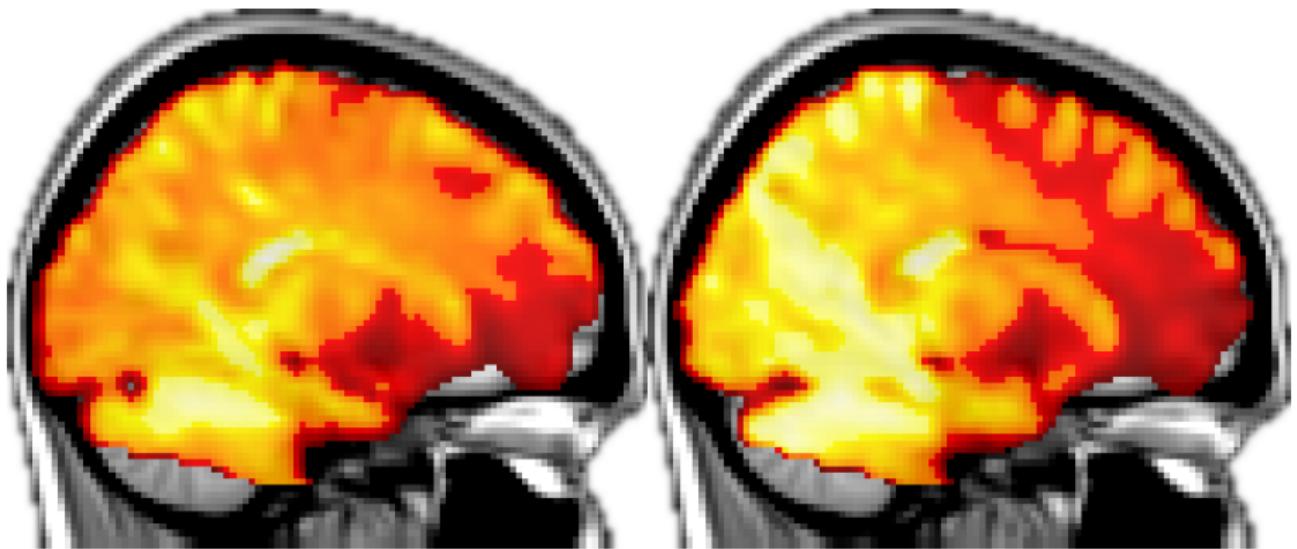


Example: Diagnostic voxels for perception of tools vs. dwellings

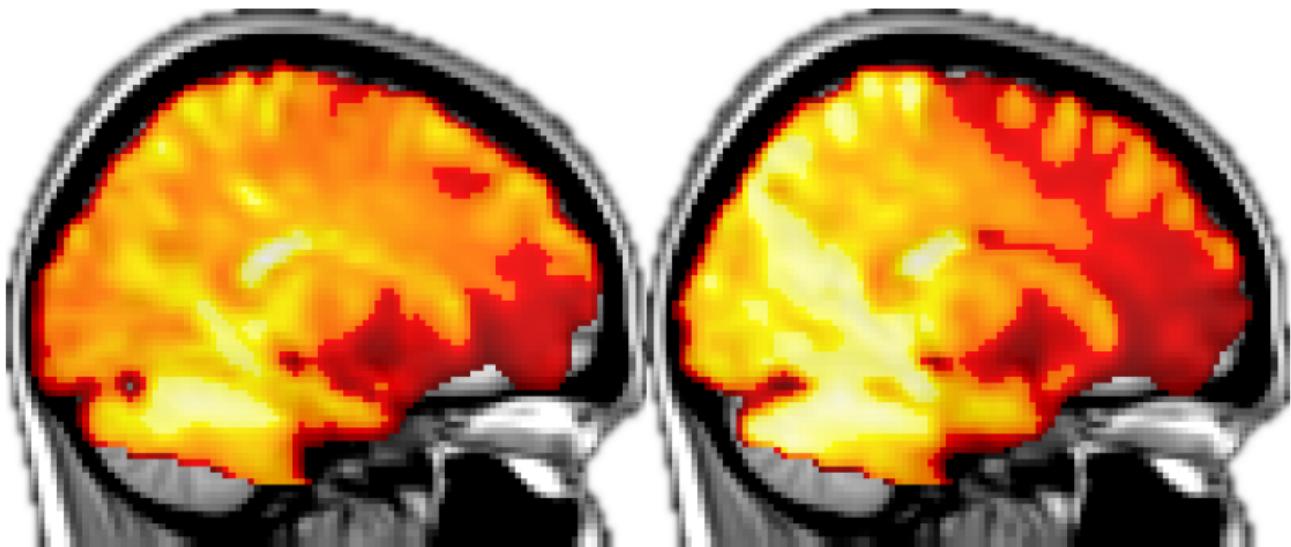
Spatial alignment



Functional alignment



Functional alignment

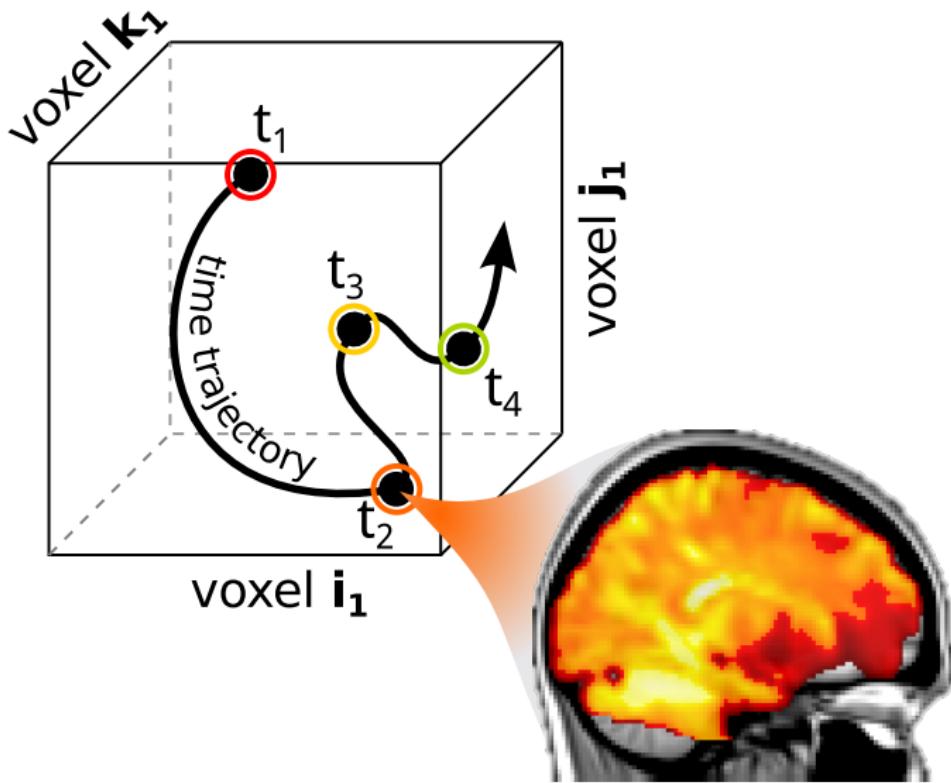


Reference space

Have: spatial/anatomical reference (MNI152; *3-dimensional*)
vs.

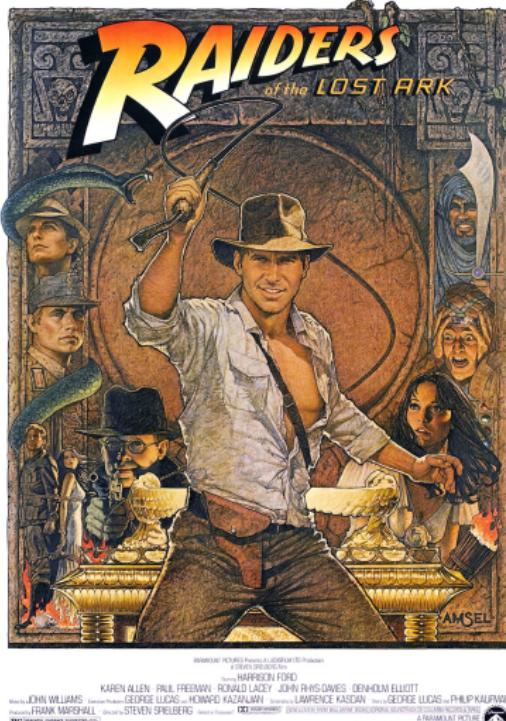
Want: functional/“brain state” reference (*n-dimensional*)

Concept: brain state space

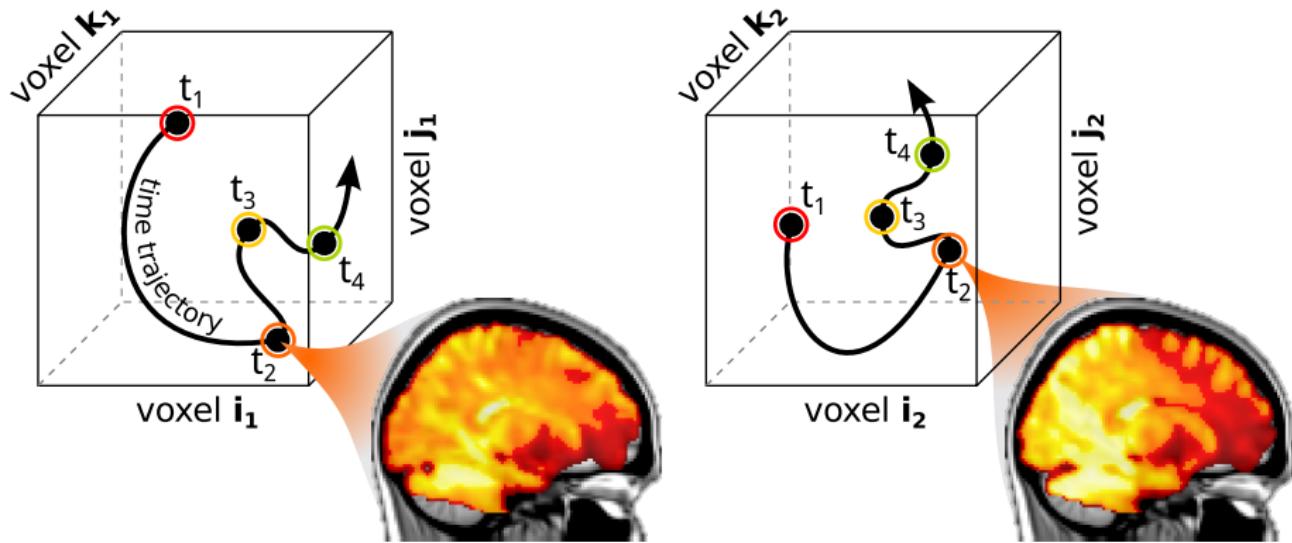


Natural stimulation

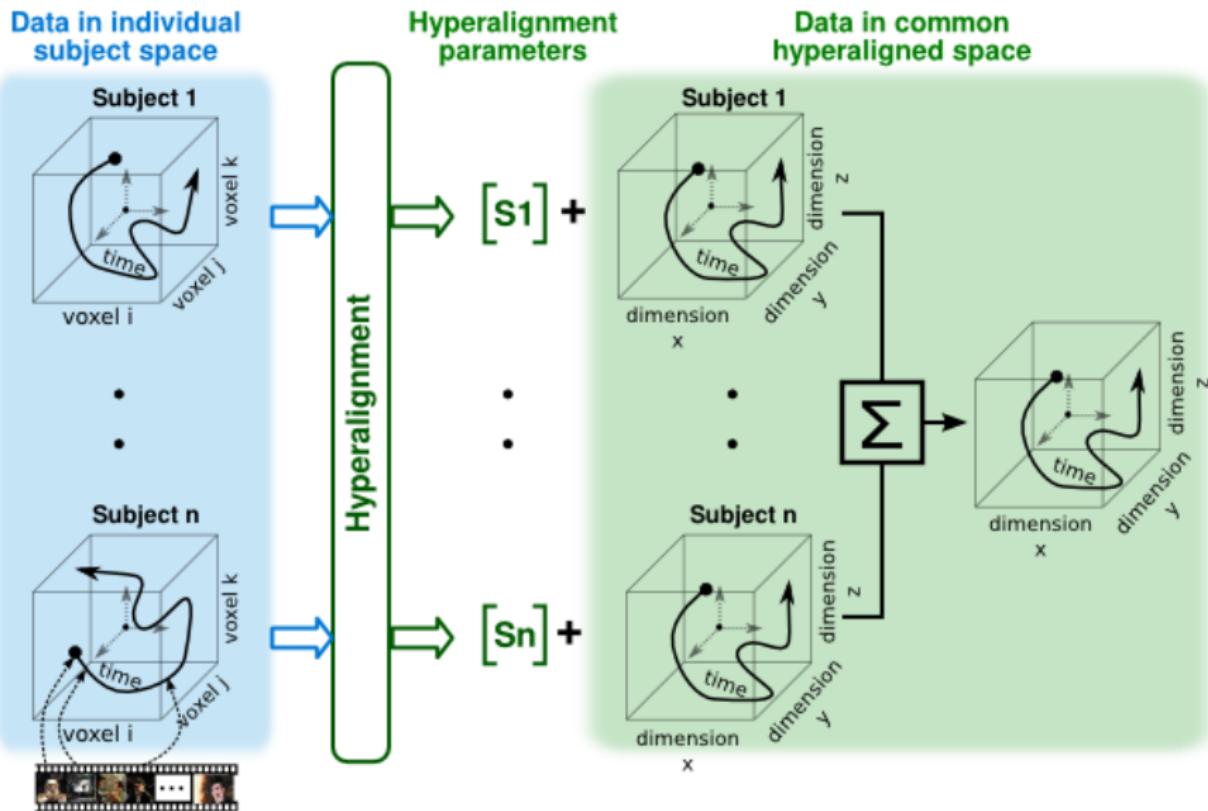
The Return of the Great Adventure.



Approach: high-dimensional functional alignment

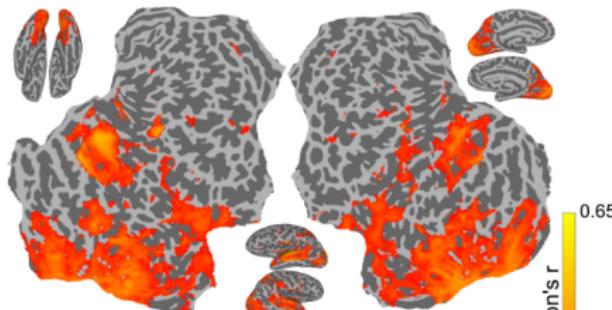


Hyperalignment: a common representational space

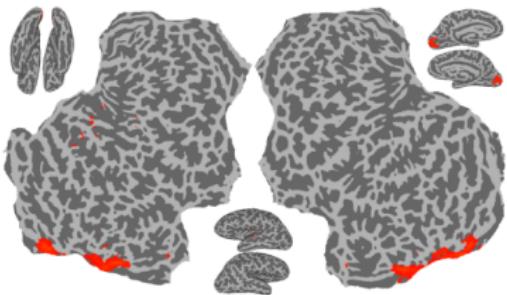


Movie time series similarity and pattern discriminability

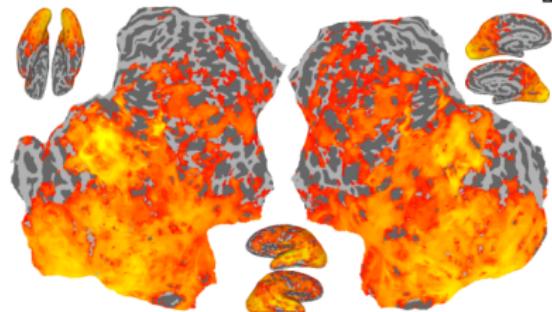
Anatomical alignment



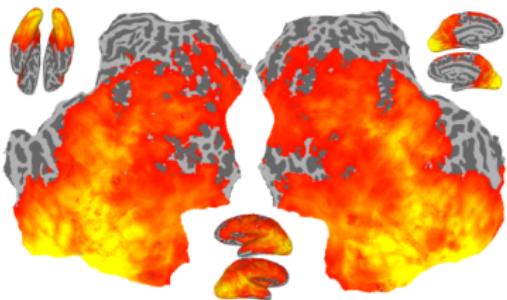
Anatomical alignment



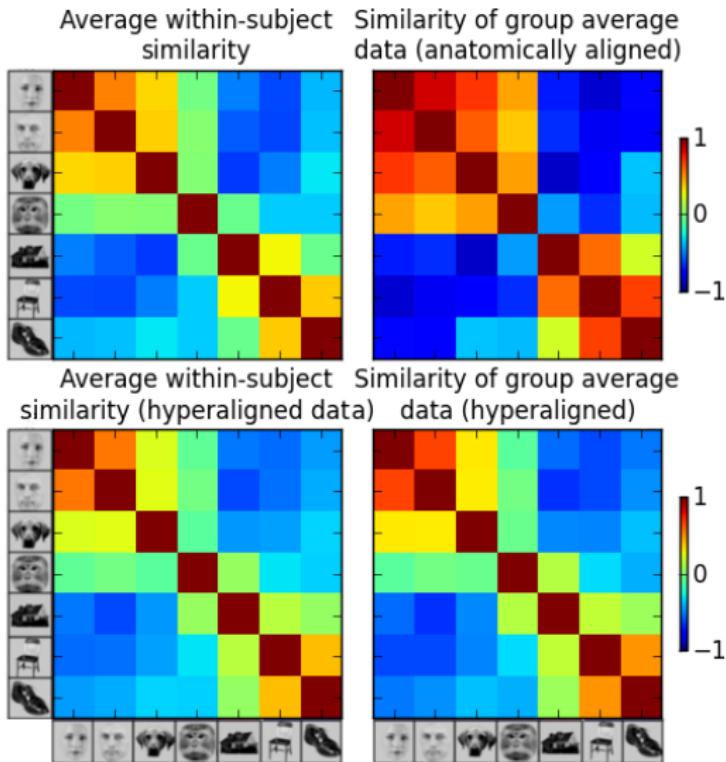
Hyperalignment



Hyperalignment



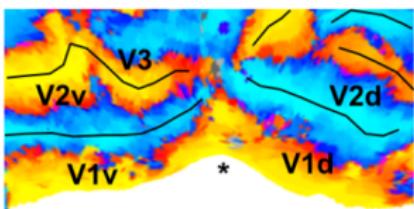
Hyperalignment: object representation similarity in VT



Hyperalignment: pattern normalization

A

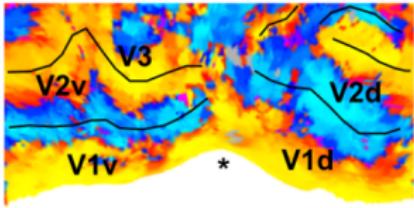
Measured polar angle map



Horizontal
meridian Vertical
meridian

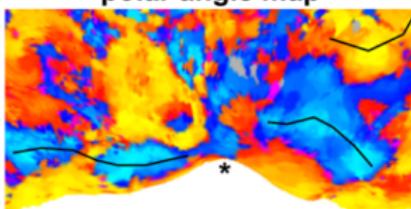
B

Hyperalignment predicted polar angle map



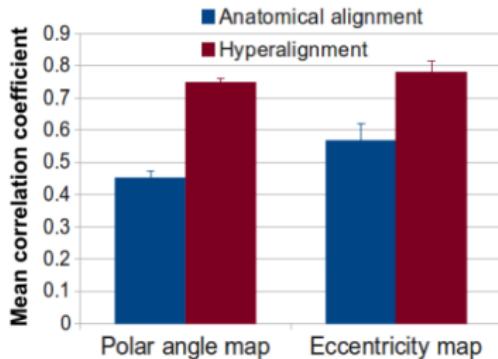
C

Anatomical alignment predicted polar angle map



D

Between-subject correlation



Starting point: auditory representational spaces

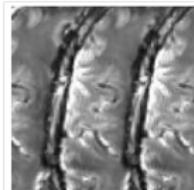


- 2 h audio movie
- story narration
- verbal scene descriptions
- “shared memory”
- wide spectrum of music
- real emotions

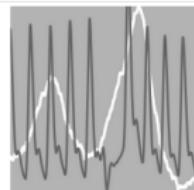
Paramount Pictures presents a Steve Tisch/Wendy Finerman production a Robert Zemeckis film Tom Hanks Forrest Gump Robin Wright Gary Sinise Mykelti Williamson
and Sally Field music by James Horner score by Alan Silvestri directed by Robert Zemeckis produced by Joel Sill edited by Arthur Schmidt written by Rick Carter, based on the novel by Winston Groom, screenplay by Eric Roth
REEL TO REEL SPECIAL EFFECTS BY WILHELMUS LOGIC INC.

Real-life cognition challenge

- 20 participants (plus phantom)
- 2 hours of fMRI (7 Tesla Siemens Magnetom, 2 s TR, 1.4 mm)
- 0.3 mm ToF angiography
- simultaneous physiological data (respiratory, cardiac)
- 0.7 mm T1w, T2w, DWI, SWI (Philips Achieva)
- reproducible stimulus
- 12-page methods description



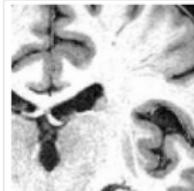
Functional MRI



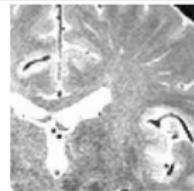
Physiological measurements

shots[5] :
{"audible_ad": ["forrest", "bubba"], "noise_level": "music_genre": "rock"}

Annotations & surveys



T1-weighted MRI



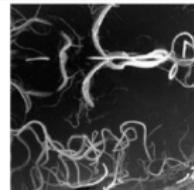
T2-weighted MRI



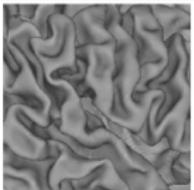
Susceptibility-weighted MRI



Diffusion tensor MRI



Angiography



Surface reconstruction

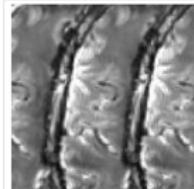
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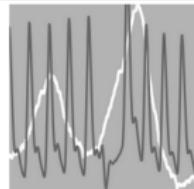
Everything available at

<http://studyforrest.org>

and 5000 EUR on top!



Functional MRI



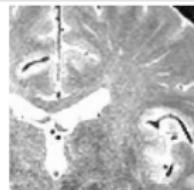
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shots[5] :
{"audible_ac":
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Annotations & surveys



T1-weighted MRI



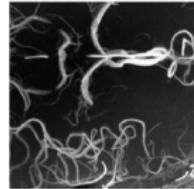
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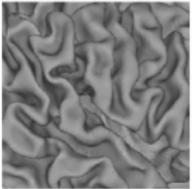
Susceptibility-weighted MRI



Diffusion tensor MRI



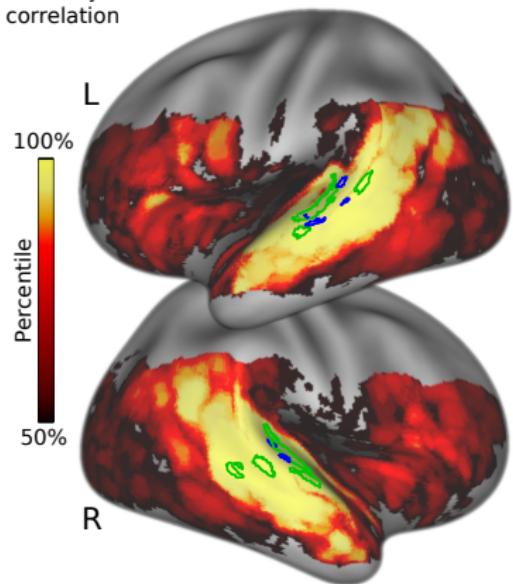
Angiography



Surface reconstruction

Data QA

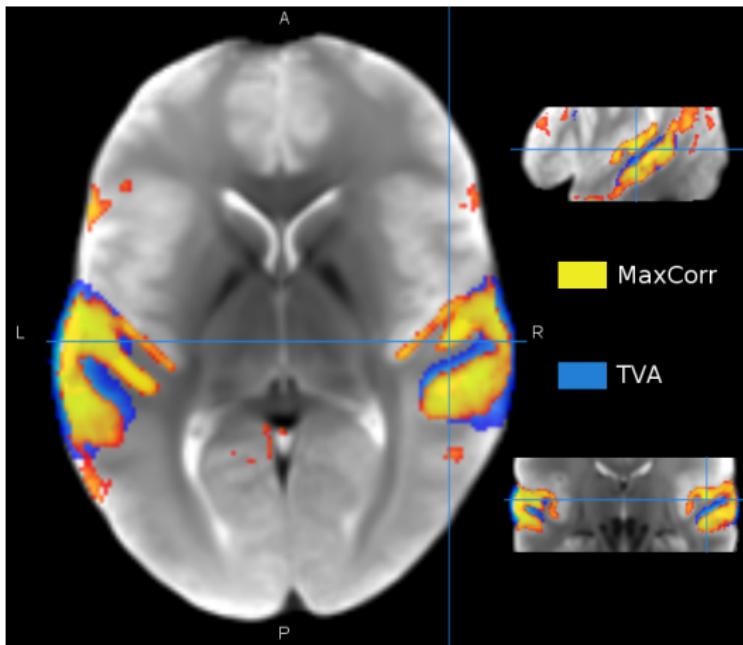
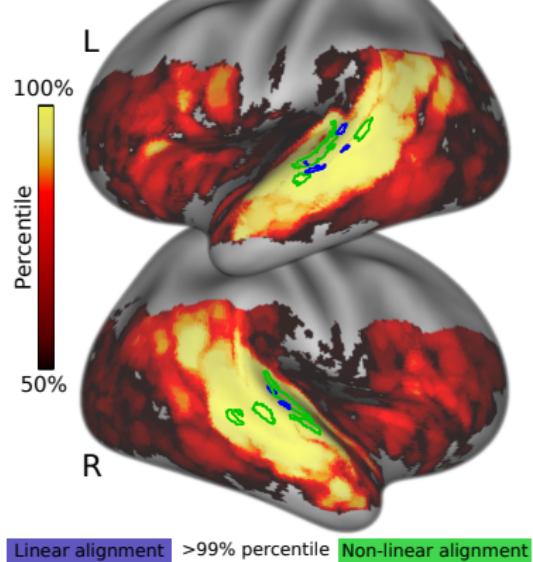
Inter-subject
correlation



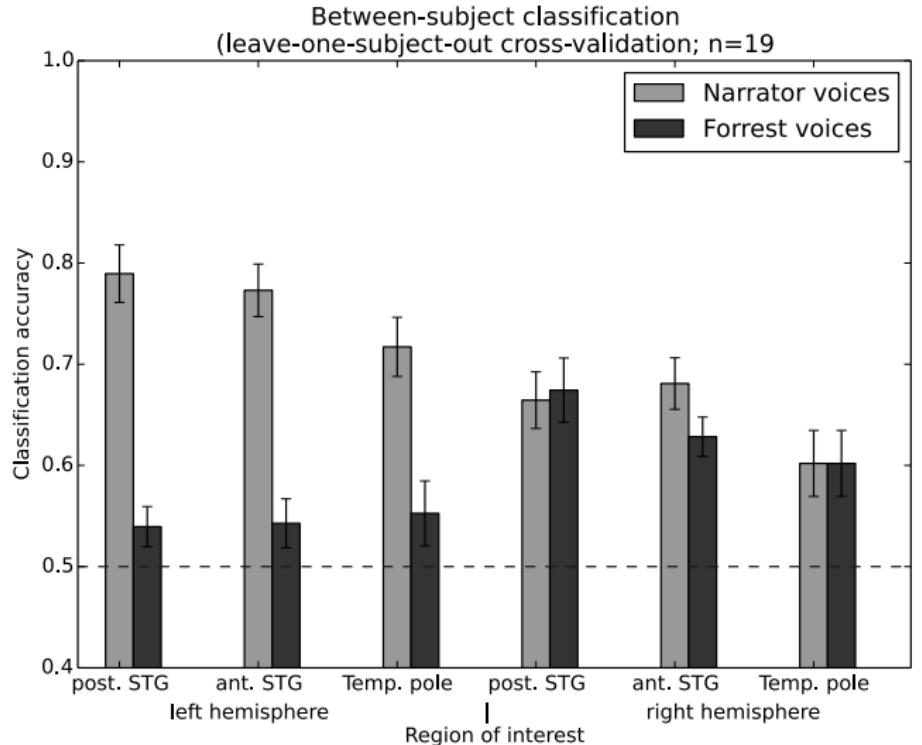
Linear alignment >99% percentile Non-linear alignment

Data QA

Inter-subject
correlation



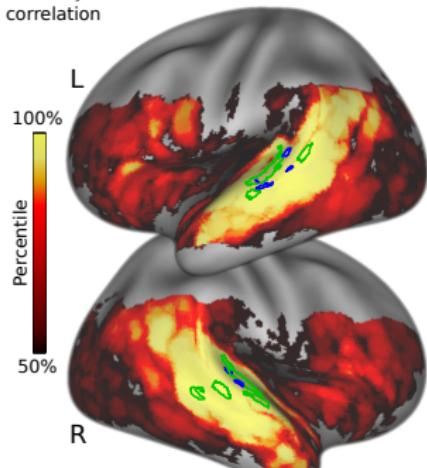
Exploration: Using the movie itself for analysis



Complete dialog annotation will be published

Hyperalignment test

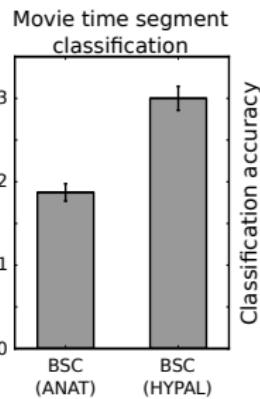
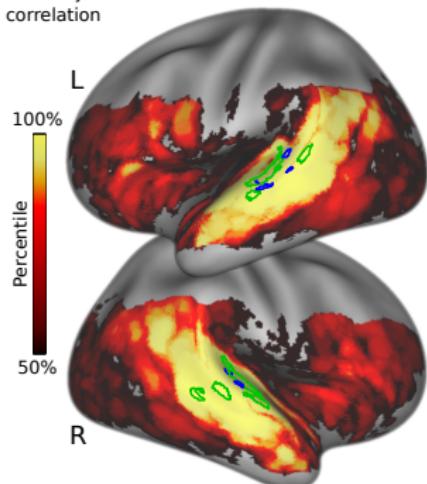
Inter-subject
correlation



Linear alignment >99% percentile Non-linear alignment

Hyperalignment test

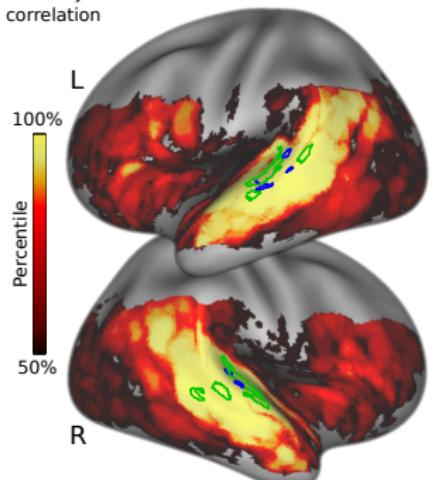
Inter-subject
correlation



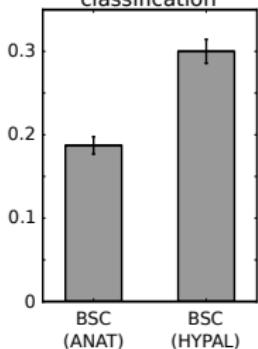
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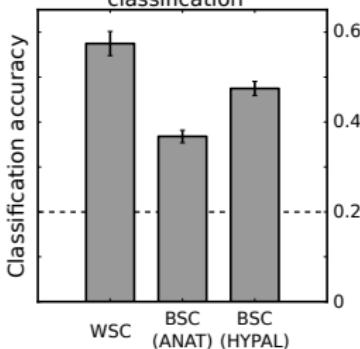
Inter-subject
correlation



Movie time segment
classification



Musical genre
classification

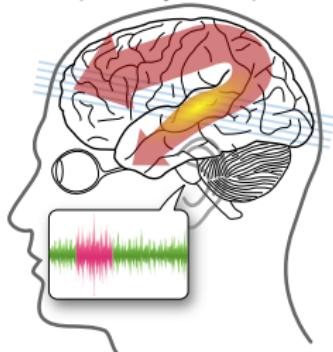


Linear alignment >99% percentile Non-linear alignment

Task fMRI is scheduled for release Q4/2014

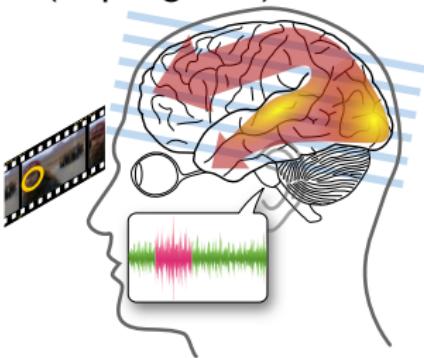
More public data

Phase 1
(complete)



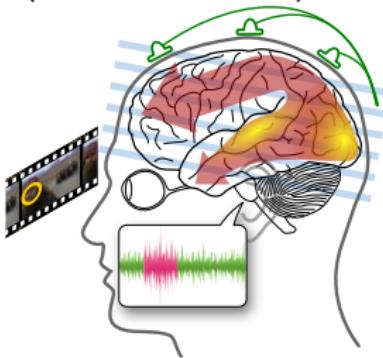
7T
auditory

Phase 2
(in progress)



3T
audio-visual
eye-tracking

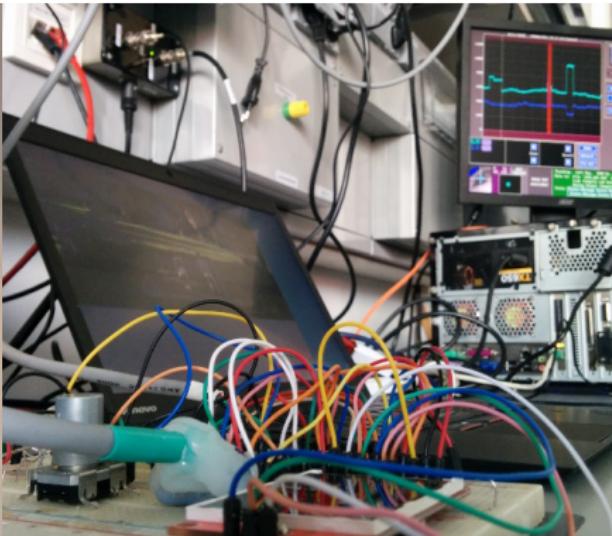
Phase 3
(est. Oct. 2014)



3T
audio-visual
eye-tracking, EEG

Dedicated eye-tracking with GSR and facial expressions is in the works.

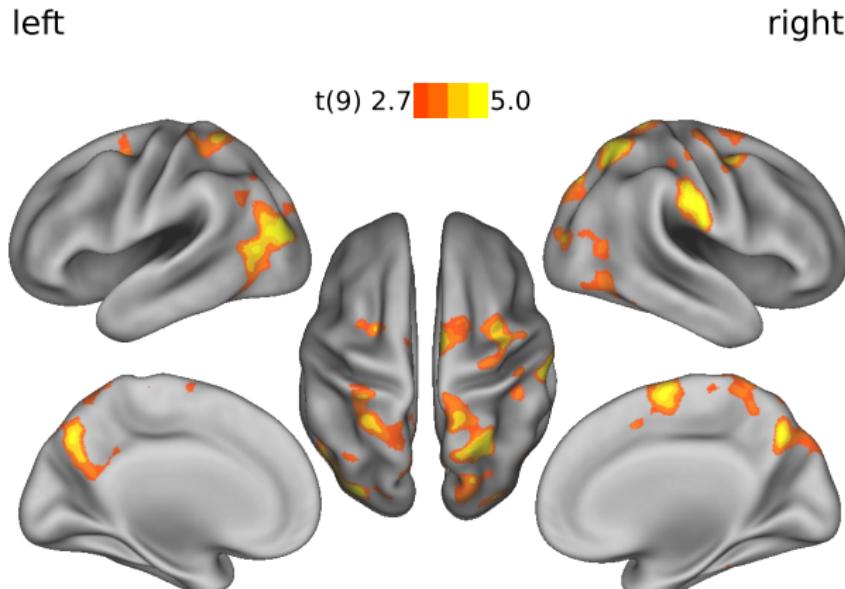
Simultaneous 3T fMRI and 1000 Hz eye-tracking



Watch data preview . . .

14 participants overlap with phase 1 data; watch data preview

RSA analysis for temporal eye-gaze synchronicity

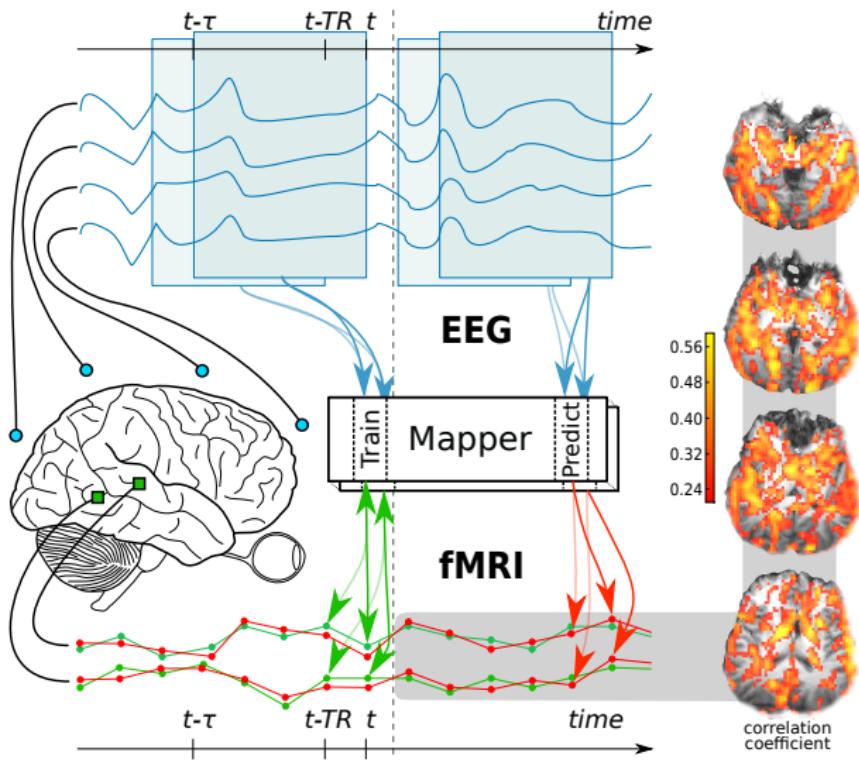


“where is fMRI signal more similar when subjects’ eye-gaze is synchronous”

→ large parts of the fronto-parietal attention network

n=10; cluster threshold ($t=2.7$, $p=.05$): FEF, SEF, IPS, hMT+, Precuneus

EEG/fMRI



Halchenko, Y. O. and Hanke, M. (2010). Advancing Neuroimaging Research with Predictive Multivariate Pattern Analysis (MVPA). *The Neuromorphic Engineer*

Datamanagement

- sizable dataset: initial release \approx 10000 files; 355Gb
- longitudinal changes: currently at post-publication-revision 3; three more major additions planned
- multiple hosting locations: OvGU, OpenFMRI, NITRC-IR, ...

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DataGit*

- version control for data: track everything
- distributed: obtain, modify, re-publish – without a central gatekeeper
- a tool, not a service – built atop of git-annex
- facilitate incremental research on a data-level

Name needs to change because of people with lawyers...

References

- Connolly, A. C., Guntupalli, J. S., Gors, J., Hanke, M., Halchenko, Y. O., Wu, Y.-C., Abdi, H., and Haxby, J. V. (2012). Representation of biological classes in the human brain. *Journal of Neuroscience*, 32:2608–2618. PMC3532035.
- Halchenko, Y. O. and Hanke, M. (2010). Advancing Neuroimaging Research with Predictive Multivariate Pattern Analysis (MVPA). *The Neuromorphic Engineer*.
- Hanke, M., Halchenko, Y. O., Sederberg, P. B., Olivetti, E., Fründ, I., Rieger, J. W., Herrmann, C. S., Haxby, J. V., Hanson, S. J., and Pollmann, S. (2009). PyMVPA: A unifying approach to the analysis of neuroscientific data. *Frontiers in Neuroinformatics*, 3(3). PMC2638552.