



MRC Cognition
and Brain
Sciences Unit



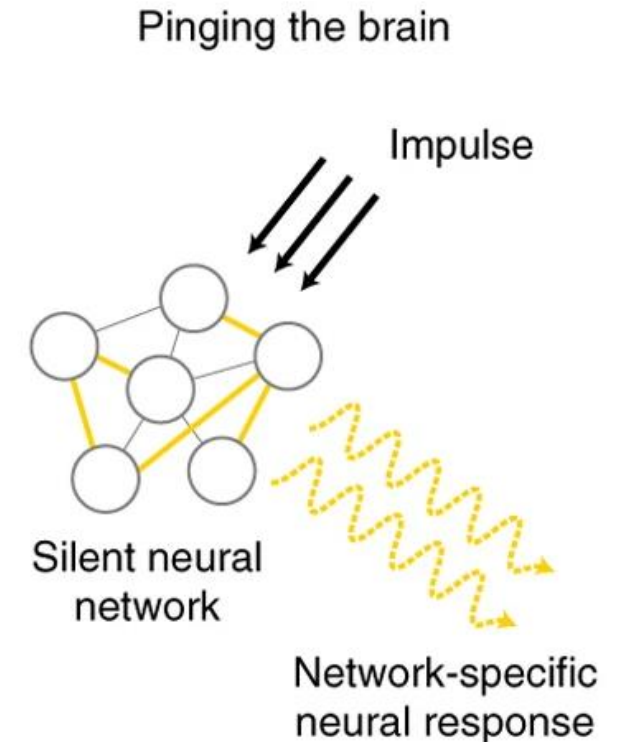
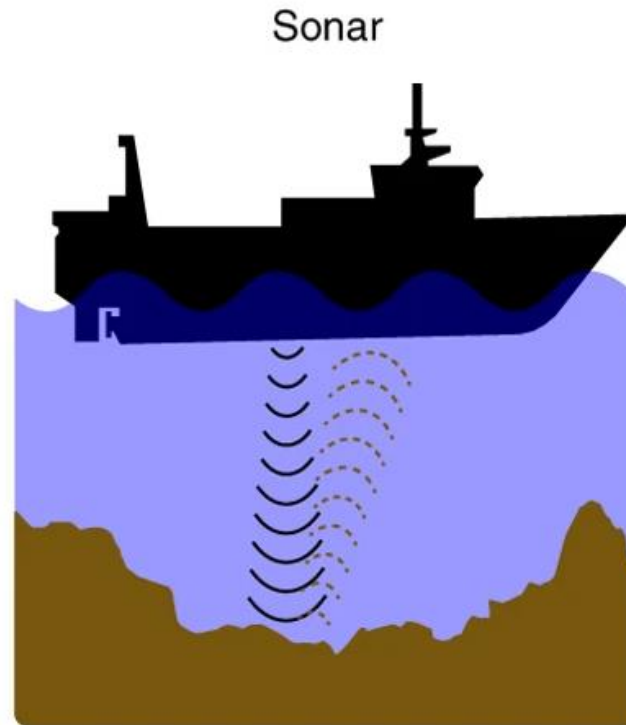
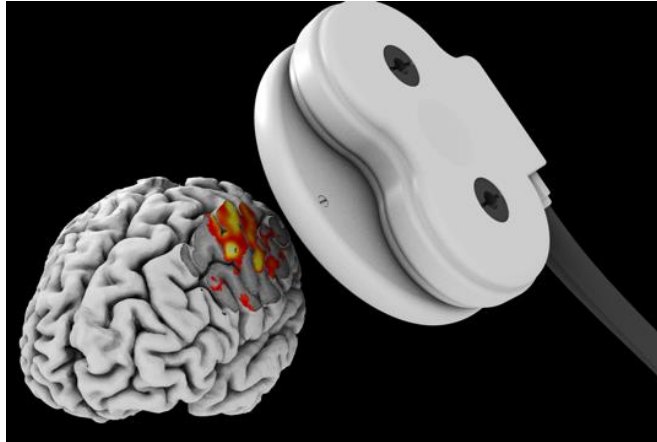
UNIVERSITY OF
CAMBRIDGE

A novel concurrent TMS-fMRI setup for high resolution whole brain imaging

Moataz Assem

Senior Research Associate
Wellcome Early Career Fellow
MRC CBU

The potential of concurrent TMS-fMRI



- Understand mechanisms of different TMS protocols

Tik et al (2017) NeuroImage

- TMS-induced fMRI activity is predictive of clinical response to interventions

Oathes et al (2023) Nature Mental Health

- Causal mapping of cognitive processes

Jackson et al (2021) Comm Biology

- Anatomical mapping of hidden brain states

Rose et al (2016) Science

Image 1 from <http://www.fmri.at/research/combining-tms-fmri-approaches/>
Images 2&3 from Wolff et al Nature Neuroscience 2017

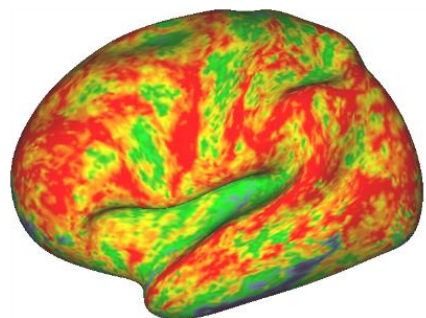


Concurrent TMS-fMRI: An international consensus and functional guide for current and future researchers

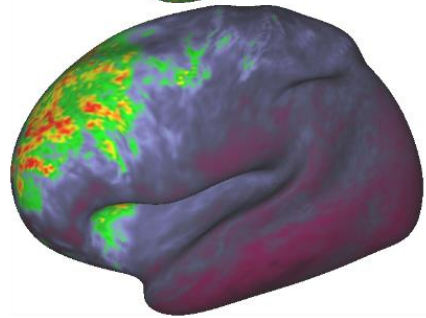
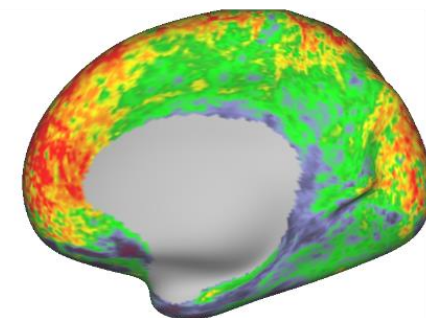
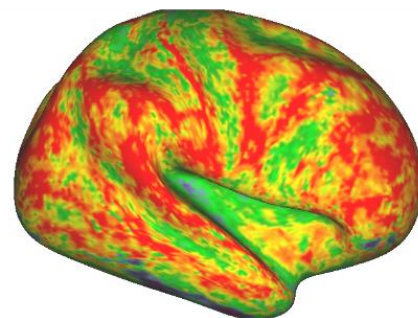
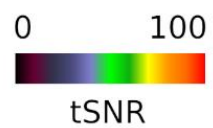
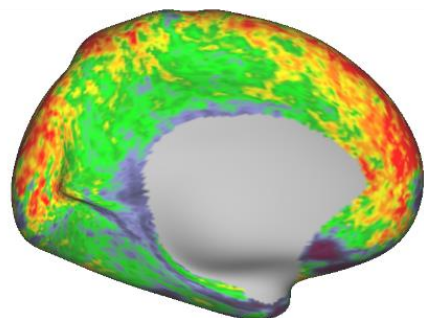
AUTHORS

Alexandra Woolgar, Eva Feredoes, Moataz Assem, Yasmine Bassil, Til Ole Bergmann, Lysianne Beynel, Michael Burke, OSFHomeRego, Roch Comeau, Marta Correia, Erhan Genç, Gesa Hartwigsen, Jade Buse Jackson (Savun), Matthias Kienle, Patrik Kunz, Olga Leticevscaia, Bruce Luber, Maximilian Lueckel, Claus Mathiesen, Elizabeth Michael, Ole Numssen, Desmond Oathes, Allyson Rosen, Teresa Schuhmann, Anna-Lisa Schuler, Catriona L Scrivener, Axel Thielscher, Martin Tik, Yordan Todorov, Maria Vasileiadi, Christian Windischberger, Molly Hermiller, and A.T. Sack

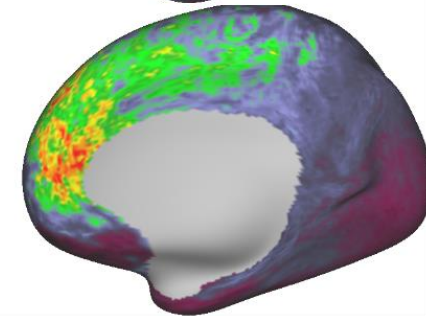
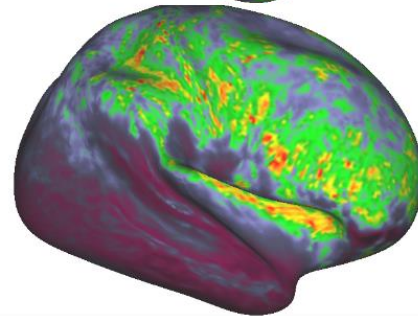
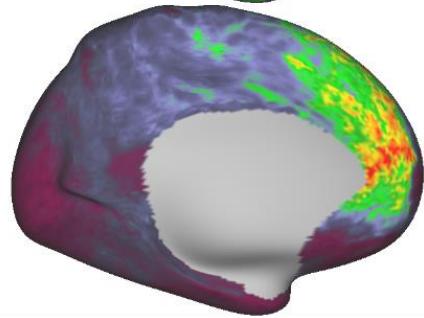
<https://osf.io/preprints/psyarxiv/9fyxb>



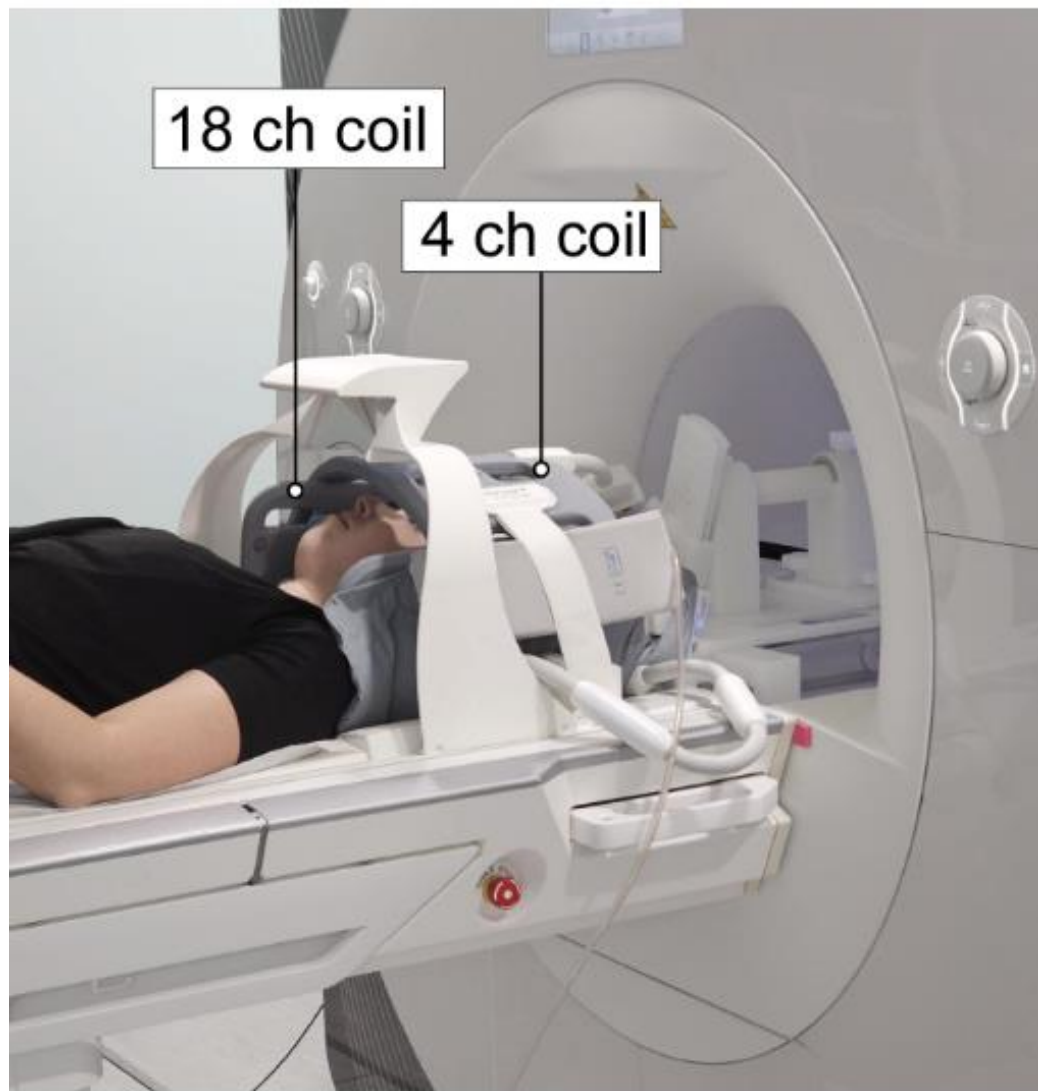
HCP seqs
standard 32 ch
MB8 - 2.00mm



Surface coils
14ch
MB4 - 2.6mm



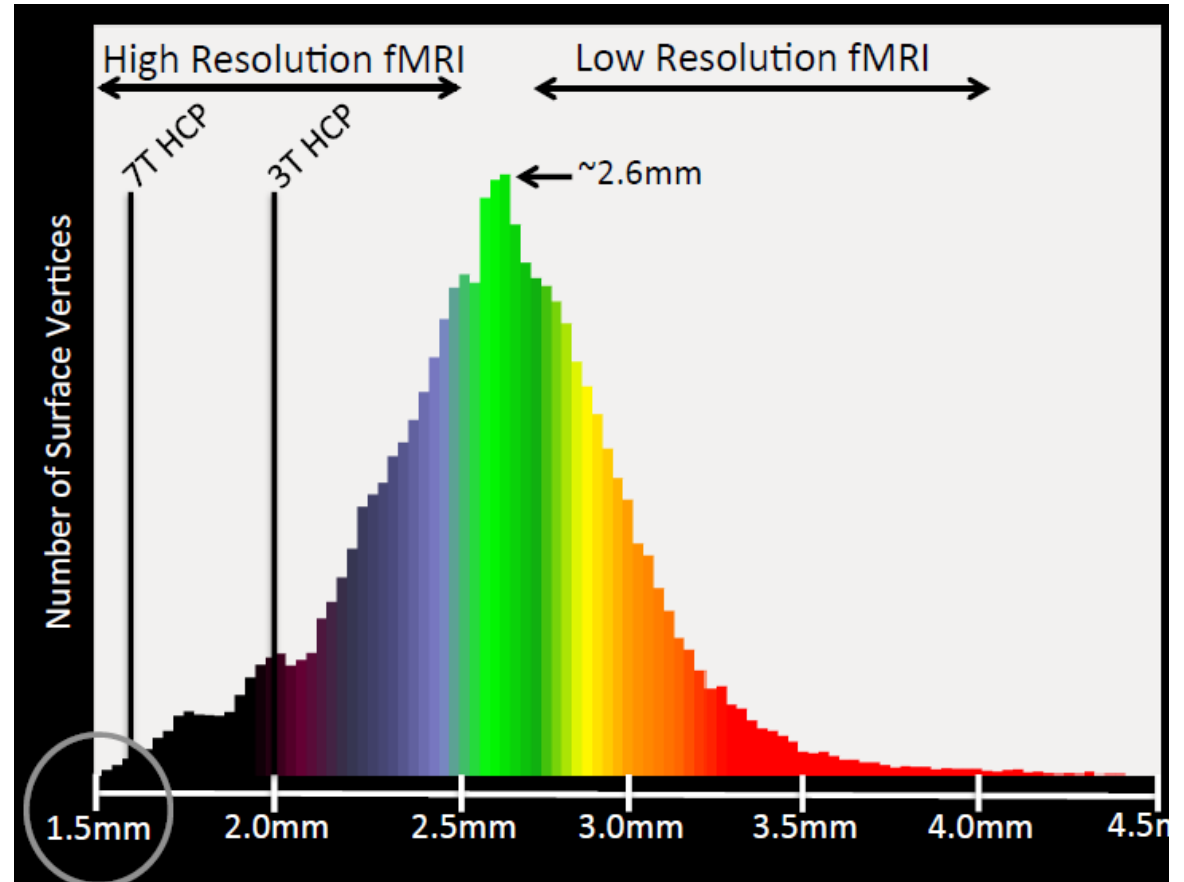
Novel TMS setup 22 ch



HCP's neuroimaging approach

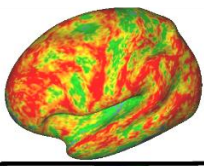
(Glasser et al Nature Neuroscience 2013)

- Voxel size (≤ 2.6 mm)
 - Better separation of GM, WM, CSF
 - More accurate surface mapping
- TR (~ 1 sec)
 - Artifacts occur at higher frequencies > easier to remove with e.g. sICA+FIX
 - Emerging evidence that some BOLD components occur at higher frequencies

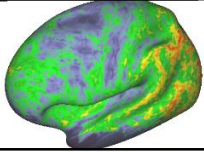
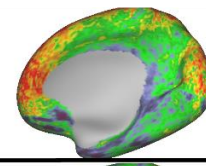
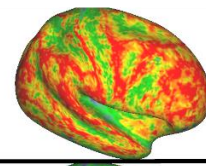
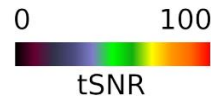
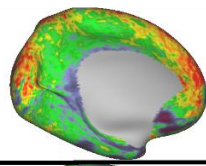




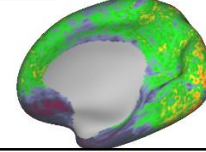
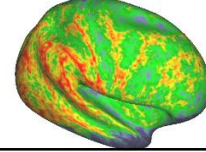
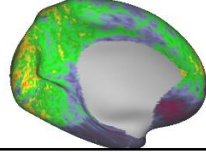
32 ch



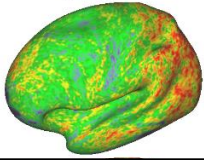
HCP seqs
standard 32 ch
MB8 - 2.00mm



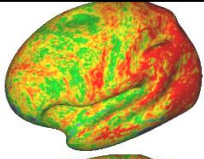
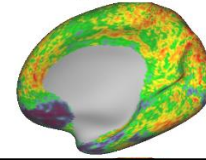
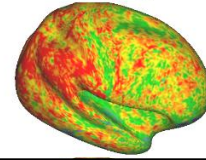
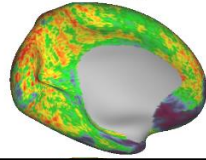
MB4 - 2.0mm
TR 1.1s
48 slices



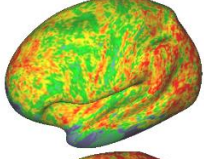
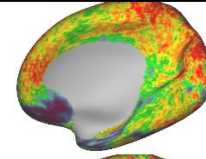
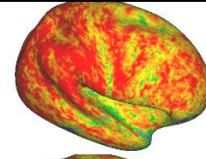
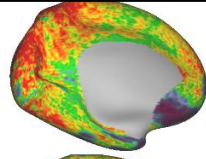
Flex 22ch coils
prescan normalize ON



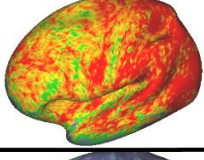
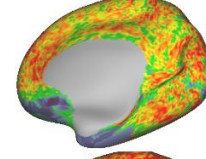
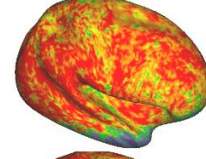
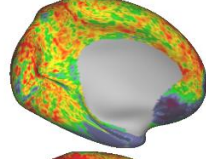
MB4 - 2.4mm
1.1s
52 slices



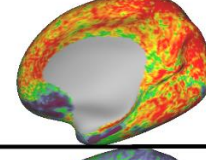
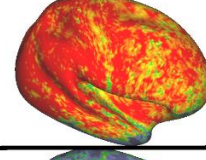
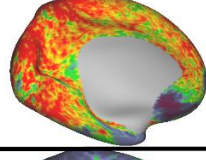
MB4 - 2.6mm
TR 1.0s
48 slices



MB2 - 2.4mm
TR 1.6s
40 slices

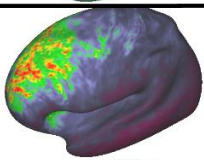


MB2 - 2.6mm
TR 1.6s
40 slices

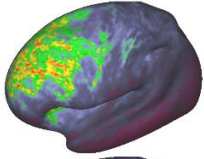
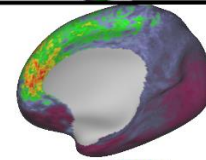
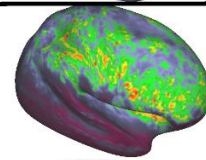
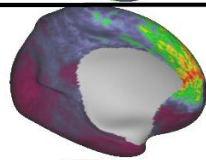


22 ch

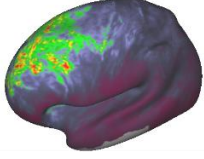
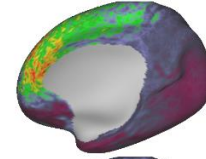
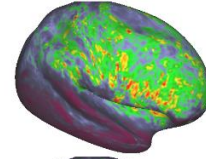
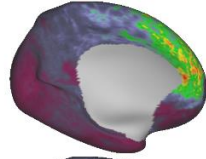
Surface 14ch coils
prescan normalize OFF



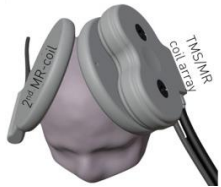
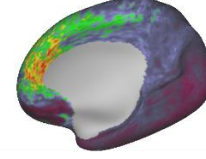
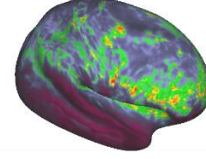
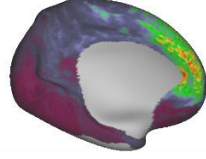
MB4 - 2.6mm
TR 1.0s
48 slices



MB4 - 2.4mm
TR 1.1s
52 slices



MB2 - 2.4mm
TR 1.6s
40 slices



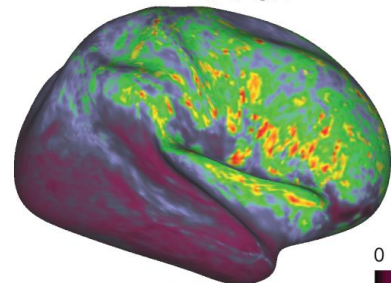
14 ch

A novel *combined* TMS - precision fMRI setup

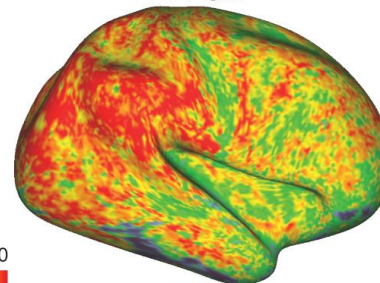
14 channels



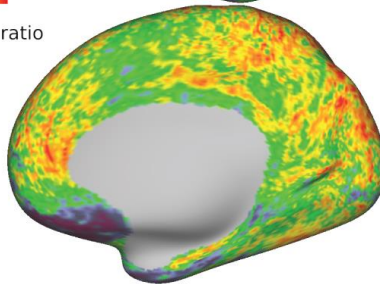
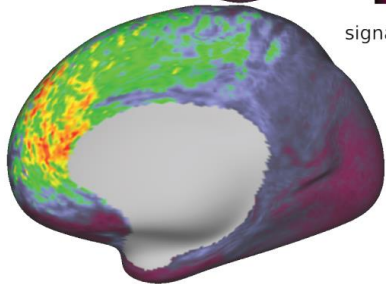
Best existing TMS setup
14 ch



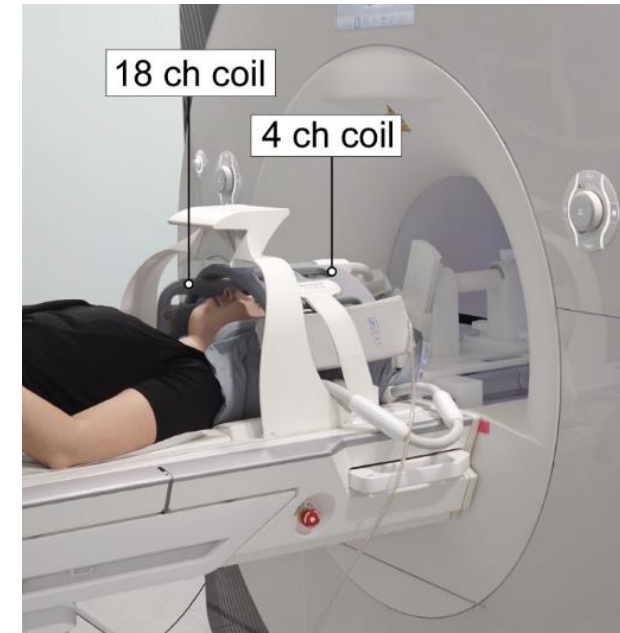
Novel TMS setup
22 ch



0 100
temporal
signal-to-noise ratio



22 channels



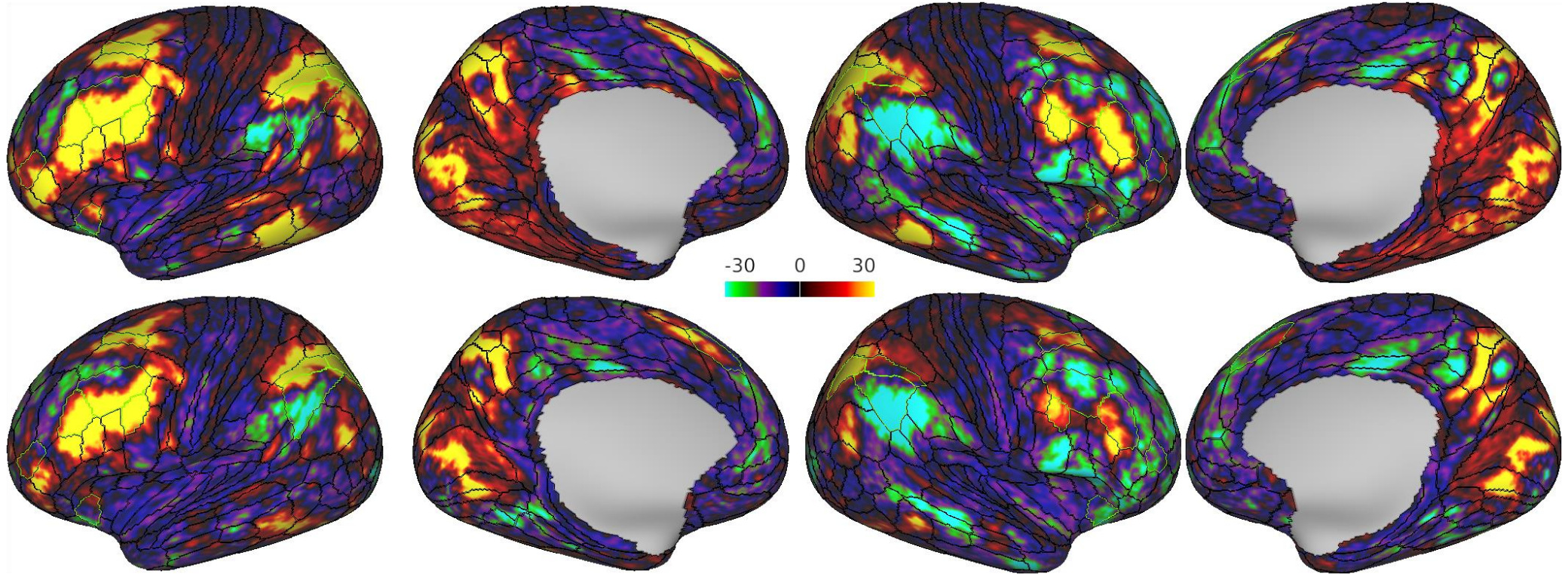
Task fMRI maps (n=11)



32 ch

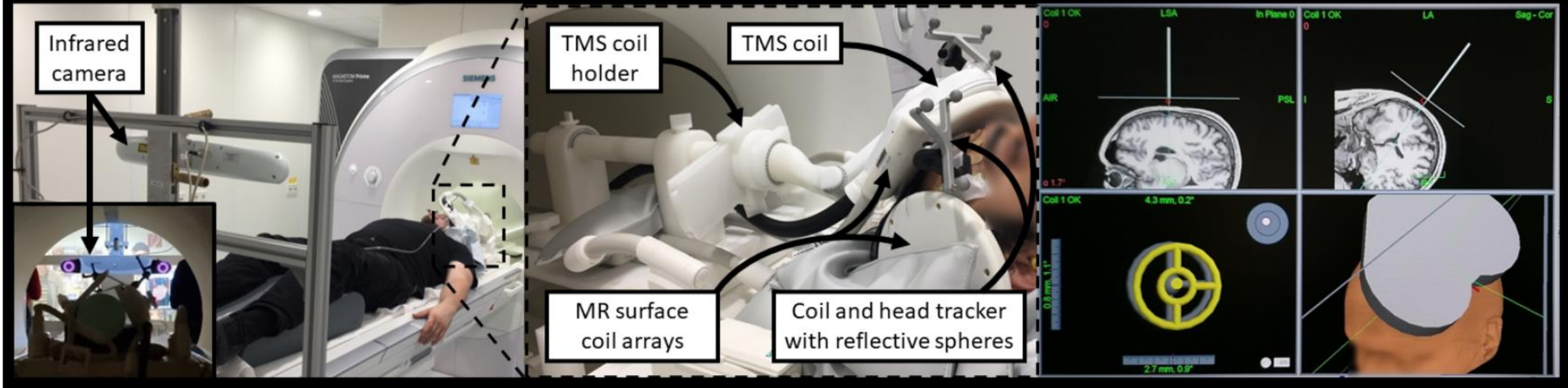


22 ch



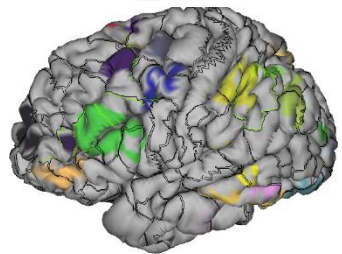
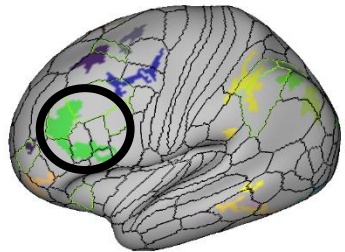
Neuronavigation

A Online neuronavigation and real-time monitoring of TMS coil placement inside the MRI scanner bore



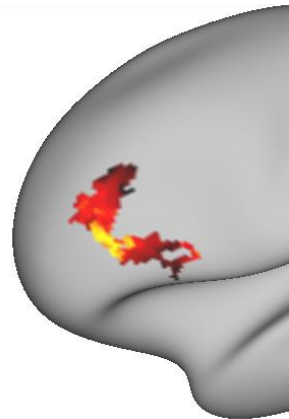
Semi-automated target definition

1. Identify significant clusters

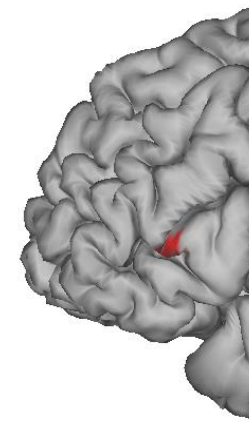
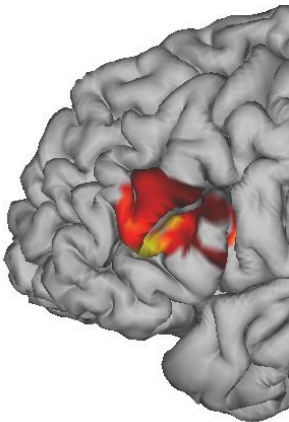
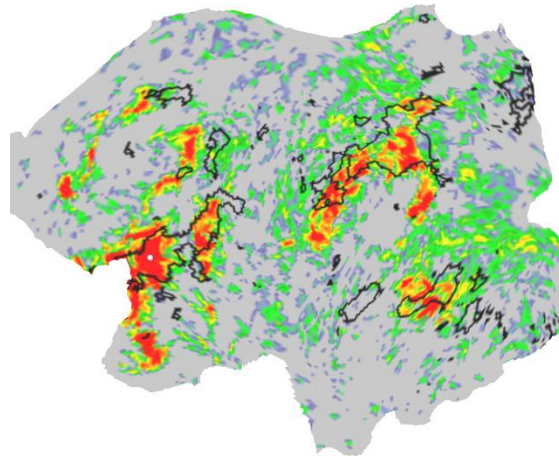


Task activation
&
On a gyrus

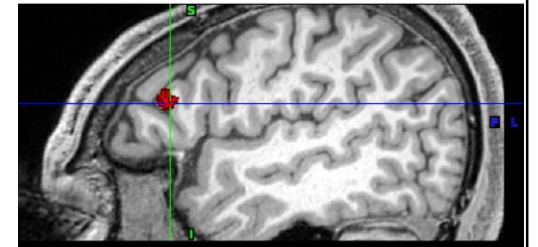
2. Refine selected cluster



Based on similarity of
rfMRI connectivity to the
switch network

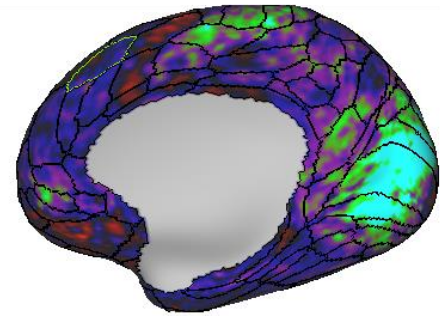
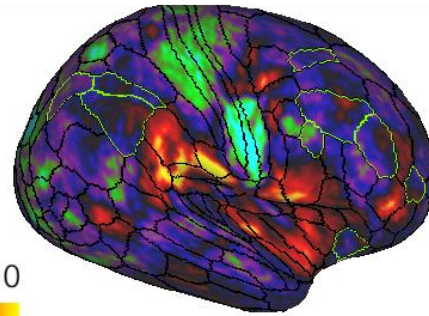
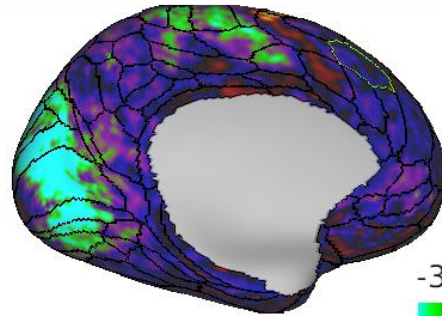
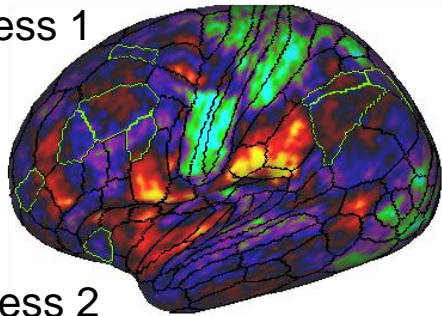


3. Transform to subject native space

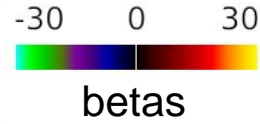
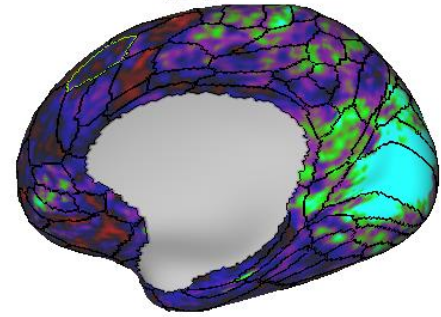
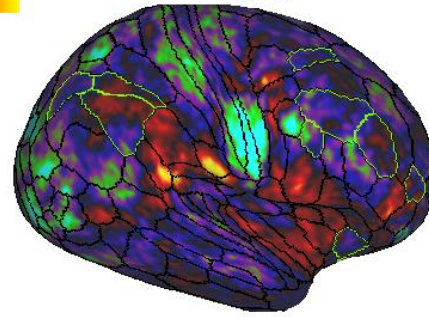
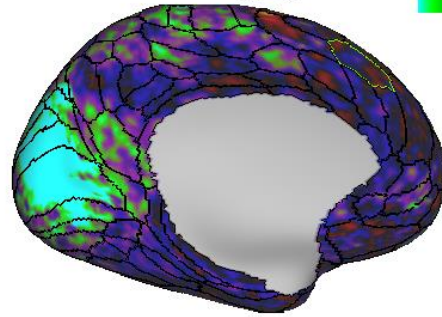
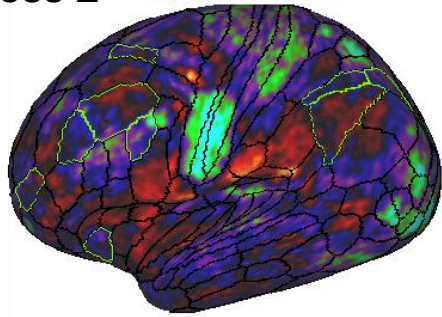


TMS vs fix univariate activations

TMS sess 1

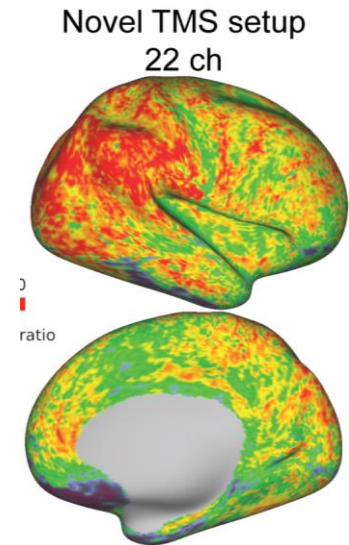


TMS sess 2



Acknowledgments

- Alex Woolgar and team (esp. Elizabeth Michael)
- CBU MRI team
 - Marius Mada
 - Steve Eldridge
 - Marta Correia
- CBU tech team



Pinging the brain

