MichaelXCohen

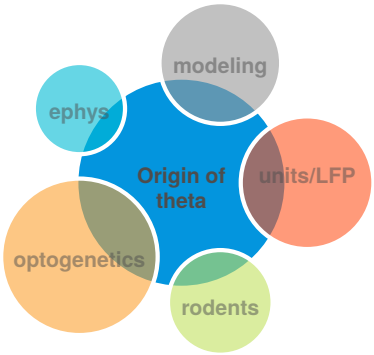
neuroscientist, writer, teacher

Main scientific projects

Electrophysiological signature of response conflict

"Response conflict" is the phenomenon of multiple response options simultaneously active when only one is goal-relevant. It's the feeling you have when you are about to walk into another person and don't know whether you should go left or right.

We find an idiosyncratic spatial-temporal-spectral feature of human EEG observed during response conflict and other cognitive control operations. This feature is called "midfrontal theta" because it is maximal over midfrontal scalp regions and is dominated by theta (~6 Hz) oscillations. We use human cognitive electrophysiology experiments to link midfrontal theta to response conflict behaviors (e.g., decision-making, keyboard typing, visual-motor control).

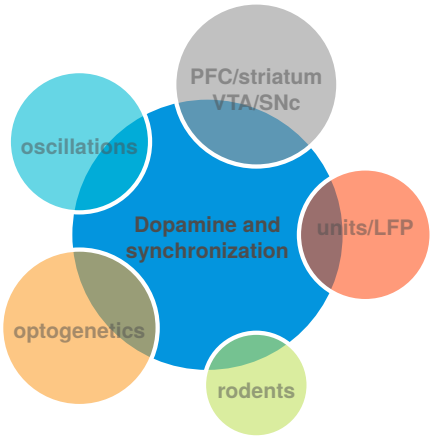


Our research shows a highly statistically robust link between midfrontal theta and response conflict detection and resolution, both within- and across-subjects. Midfrontal theta is also non-phase-locked to stimulus or response, suggesting that it reflects amplitude modulations of ongoing rhythmic activity, as opposed to an evoked additive response.

Mechanisms of PFC theta oscillations

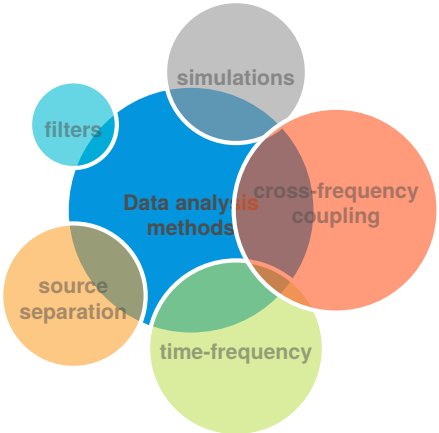
What neural circuit mechanisms produce midfrontal theta and conflict computations? This is an important question, yet has no good answer.

We use high-density multisite and multiarea electrophysiology in combination with optogenetics and electrical microstimulation (in rodents) to discover circuit mechanisms of frontal theta. These findings are integrated with biophysical computational models.



Phasic dopamine and neural synchronization

We use large-scale electrophysiology and optogenetics in Th:Cre rats to understand how optically indiced phasic up/down-regulation of dopamine regulates synchronization in PFC-striatal-VTA circuits.



Data analysis methods development and evaluation

Neuroscience is awash with data analysis methods, yet many methods lack rigorous testing of parameter ranges and violations of key assumptions in empirical data. We simulate EEG and LFP data to evaluate existing, and develop new, cutting-edge analysis methods. Simulations are useful because they maximize control over signal and noise characteristics.

Scientific funding and awards

Current

2017-2022 **RUMC Principal Investigator award** 100k€ / year
PI status awarded at the Radboud University Medical Center for top scientific excellence and leadership.

2017-2021 **Junior-researcher award: "Brain rhythms of posture control: Cortical mechanisms and implications for Parkinson's disease" (funds a PhD student; coPI: Dr. Vivian Weerdesteyn)** 260k€
PhD grant from Radboud University Medical Center.

2019-2023 **Junior-researcher award: "The oscillatory mechanisms behind response inhibition." (funds a PhD student)** 260k€
PhD grant from Donders Centre for Neuroscience.

2010-2022 **Radboud Excellence Initiative: "The role of serotonin on amygdalo-prefrontal neural synchronization in reward learning" (funds a postdoc; coPI: Dr. Judith Homberg)** 200k€
Grant from Radboud University Medical Center.

Previous

2015-2020 **ERC Starting: "Midfrontal theta: Causes and consequences"** 1.5M€
The goal of this ERC grant is to make discoveries about the physiological basis of midfrontal theta.

2015-2020 **Hypatia award: "Dopamine synchronizes neural networks over time and space"** 800k€
Competitive grant at the Radboud University Medical Center.

2019 **Distinguished visiting scholar**
International award and a 1-week visit to the University of Rhode Island.

2018 **ZonMW ETH Public-Private project: "Scalable, high-resolution optrodes for linking population neural activity to synchronization in the dopamine system in awake animals"** 30k€
One-year grant for developing new electrodes with Cambridge NeuroTech.

2010-2015 **VIDI, NWO: "Dynamic functional neuroanatomy of cognitive control in humans"** 800k€
5-year grant to study EEG midfrontal theta from methodological and psychological perspectives.

2009-2010 **HFSP: "Brain connectivity and mechanisms of control"** salary+slush
HFSP award for post-doc research on EEG/TMS, synchronization, and cognitive control processing in humans.

2005-2007 **NRSA F31** salary+slush
NRSA (NIDA) funding for 3 years for PhD training.

2004-2005 **DAAD** salary+slush
DAAD (German academic exchange service), Research on iEEG in epilepsy patients in Bonn.

Selected recent publications

Pubmed
pubmed.com/?term=cohen-mx

GScholar
goo.gl/k7sKWU

The numbers
 # pubs: 116 (pubmed)
H$_{idx}$: 66 (gscholar)
 # cites >17k (gscholar)

Amazon page
goo.gl/YCkPj6

Zuure MB, Hinkley LB, Tiesinga PHE, Nagarajan SS, Cohen MX
Multiple Midfrontal Thetas Revealed by Source Separation of Simultaneous M/EEG.
Journal of Neuroscience, 2020

Mishra A, Marzban N, Cohen MX, Englitz B.
Dynamics of neural microstates in the VTA-striatal-prefrontal loop during novelty exploration in the rat
Journal of Neuroscience, 2021

Cohen MX
A tutorial on generalized eigendecomposition for source separation in multichannel electrophysiology
Under review, 2021

Cohen MX
Multivariate cross-frequency coupling via generalized eigendecomposition
Elife, 2017

Cohen MX
Where Does EEG Come From and What Does It Mean?
Trends in Neurosciences, 2017

Cohen MX
A neural microcircuit for cognitive conflict
Trends in Neurosciences, 2014

Monograph textbooks

MITP page
Click here

Courses page
sincxpress.com

2021 **Linear Algebra: Theory, Intuition, Codea** SincXPress
Monograph textbook that combines in-depth comprehensive explanations, visualizations, examples, and code (Python and MATLAB) to explain concepts in linear algebra, with special focus on applications in data science.

2014 **Analyzing Neural Time Series Data** MIT Press
This monograph textbook explains the conceptual, mathematical, and implementational (via Matlab programming) aspects of time-, time-frequency- and synchronization- based analyses of MEG, EEG, and LFP recordings. The book is widely used for self-study and for a graduate-level neuroscience course on electrophysiology time series analysis.

2017 **MATLAB for Brain and Cognitive Scientists** MIT Press
This textbook brings learners from beginning to advanced skill level in the MATLAB programming language. The book offers a mix of instructive text and rigorous explanations of MATLAB code, along with programming tips and tricks and myriad exercises. Topics are centered on data analyses commonly implemented in neuroscience time series analysis, signal processing, modeling and model-fitting, statistics, and data visualization.

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twitter
Nope.

LinkedIn
Nope.

facebook
Major nope.

Teaching

2001-now **"In-vivo" teaching** varied
Full-length courses (6-8 weeks) on data analysis, statistics, scientific programming (MATLAB and Python), and cognitive neuroscience. Most courses are taught at research masters and PhD student levels.

Myriad 2-hour guest lectures on various topics, including cognitive control, data analysis, scientific programming, and neural computation.

Week-long intensive courses on (1) time-frequency analysis and (2) linear algebra. These courses are currently held as part of the Radboud Summer School.

2015-now **Youtube channel** link: youtube.com
>80 hours of lectures on data analysis, signal processing, and statistics. These lectures are specific for neural time series data (EEG, MEG, and LFP). Videos are grouped according to topic. They roughly accompany the time series book and are appropriate for use in a graduate-level course.

2017-now **Online courses (Udemy)** link: udemy.com
Online courses on signal processing, linear algebra, statistics, deep learning, and scientific coding (MATLAB and Python). See sincxpress.com for more information.

Mentoring/supervising

Current
4 PhD students
Marrit Zuure, Nader Marzban, Jordi ter Horst, Mitchel Stokkermans
2 Post-docs
Dr. Morgane Boillot, Dr. Adam Dede

Previous
PhD students
Ashutosh Mishra, Irene van de Vijver, Anderson Mora Cortes, Joram van Driel, Helga Harsay
Post-docs
Dr. Joan Duprez, Dr. Paul Anderson, Dr. Nils Borgesius, Dr. Arthur Franca, Dr. Piray Atsak
Visiting scholars
Esra Smith, Tomasz Oleksy, Zsofie Zavecz, Hause Lin, Aleksandra Kolodziej

Mentoring
Donders mentors
Academic mentor for 5 PhD students. I meet with each student annually (or as needed) to provide academic/career advice. Mentor-student pairs are selected to prevent potential conflicts of interest with PhD student's PI.

Peer coaching
4-week training course in 2017 on leading discussions and resolving potentially sensitive professional issues in small groups (3-5), including strategies for asking questions, eliciting information, and resolving conflicts.

Academic timeline

2015-present **Associate professor at Radboud University Medical Centre, Nijmegen, Netherlands, and Donders Centre for Neuroscience**
My research groups includes post-docs, technician, PhD students, several visiting self-funded scholars, and lots of research masters students.

2009-2015 **Research scientist at the University of Amsterdam, psychology department.**
My research group included 2 PhD students and several research masters students. I was initially funded by a HFSP postdoc grant, and then received an NWO VIDI grant (see page 2).

2008-2009 **Post-doctoral researcher at the University of Arizona**
I worked with Dr. Michael Frank and Dr. John Allen on computational models of cortical-basal-ganglia interactions, and EEG time-frequency analyses.

2004-2007 **Scientist at the epilepsy clinic at the University of Bonn**
Part of my PhD project was recording intracranial EEG activity in patients with epilepsy, and DBS recordings in patients with major depression and Parkinson's disease. This research was funded by DAAD from Germany, F31 (NRSA) from NIDA, and a block-grant from the psychology department at the University of California, Davis.

2001-2007 **PhD student at the university of California, Davis**
My PhD project focused on reinforcement learning, reward anticipation, and memory. The first few projects involved fMRI and computational modeling, and the later projects involved intracranial EEG. My PhD was funded by a combination of teaching salary, F31, DAAD, and R01 from my supervisor, Dr. Charan Ranganath.

1997-1999 **Undergraduate student at Carnegie Mellon University**
I entered CMU as a music student, but quickly became more interested in psychology and biology, and finished a degree in psychology.