Human Brain Project

EBRAINS

DOMINO

Development of cortical multisensory integration mechanisms at micro- and macro-scales during normal and pathophysiological conditions

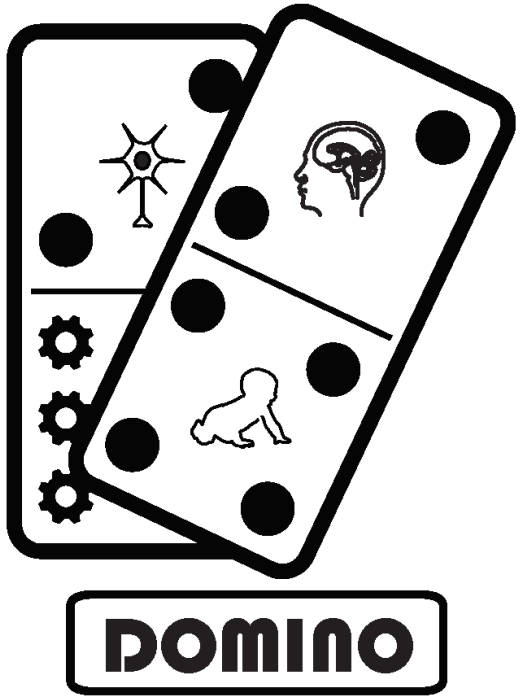
HBP Partnering Projects Meeting: Status quo & outlook

5-7 September 2022 | Nijmegen, The Netherlands

Co-funded by
the European Union

FLAG-ERA

Human Brain Project



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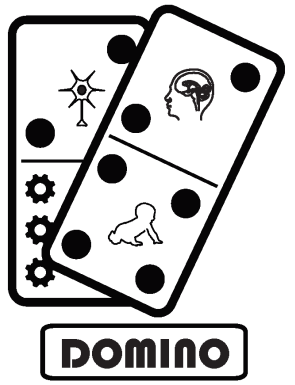
CerCo UMR5549

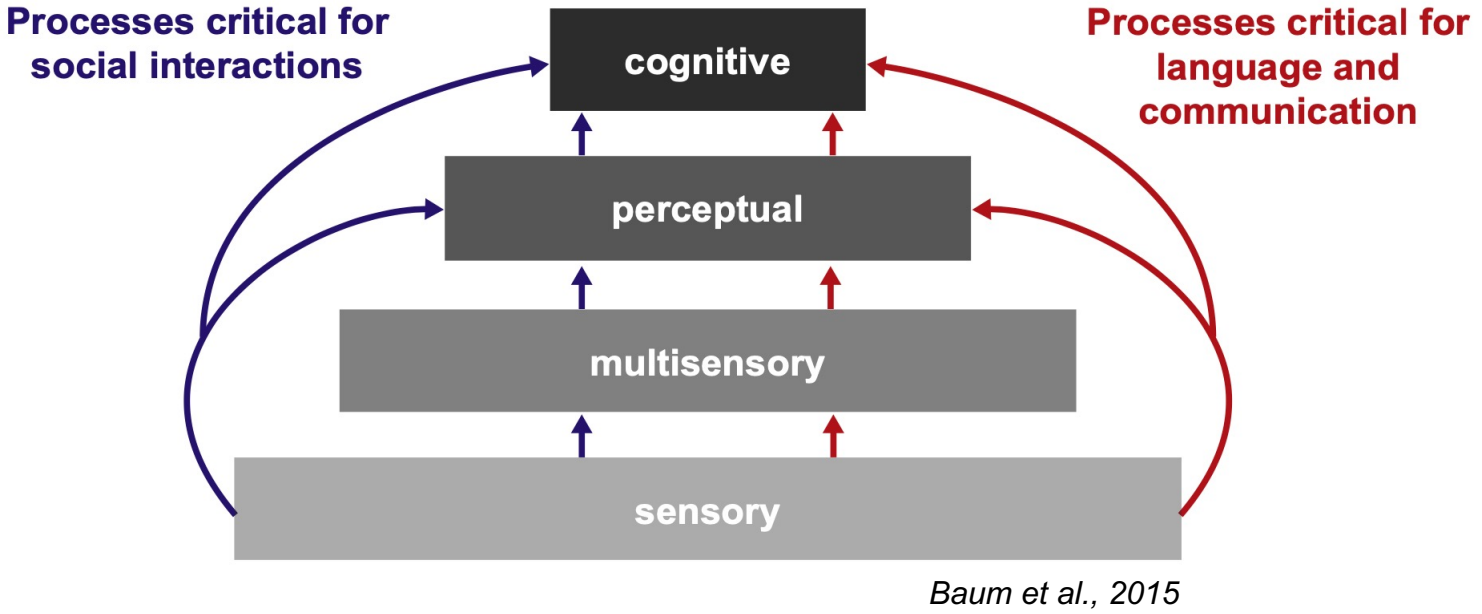
Consiglio Nazionale delle Ricerche

Panteion University

Co-funded by the European Union

Multisensory integration in autism spectrum disorders



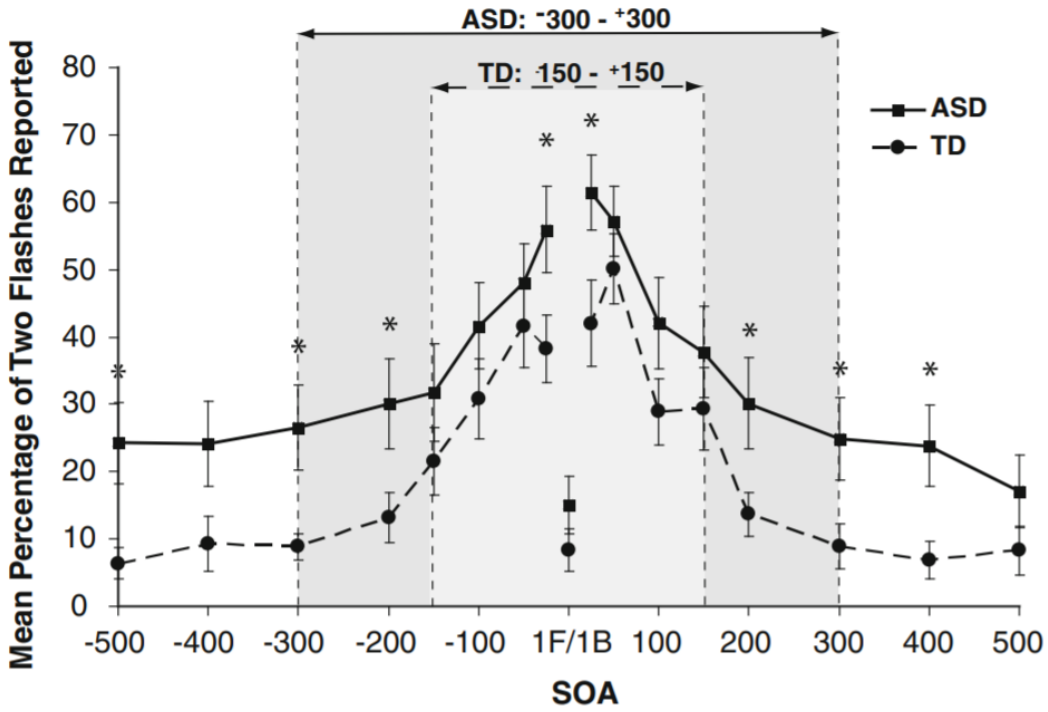


Baum et al., 2015

Impaired ability to properly integrate multiple sensory modalities has been hypothesized to underlie many of the symptoms in autism spectrum disorders (**ASD**).

However, how multisensory integration develops and how it is expressed in ASD is poorly understood.

Multisensory integration in autism spectrum disorders

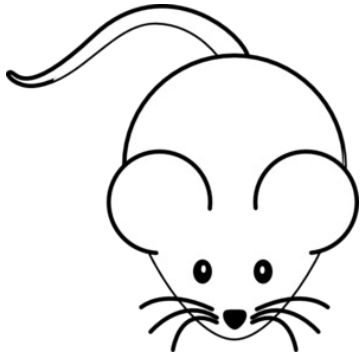


Foss-Feig et al., 2010

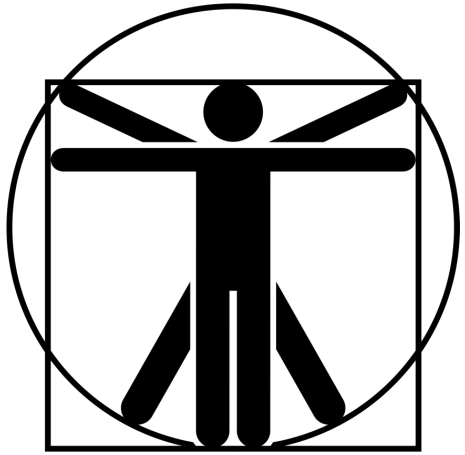
The temporal window for multisensory integration (**MI**) is extended in ASD.

Understanding how MI develops, and its disruptions in ASD is key to improve diagnosis and develop new treatments.

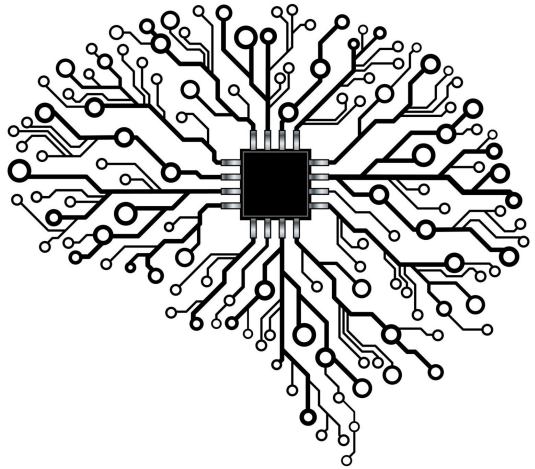
The DOMINO paradigm



Mouse experiments
- Multi-area microcircuit-level characterization of MI development
- WT and ASD mice
- From birth to adulthood

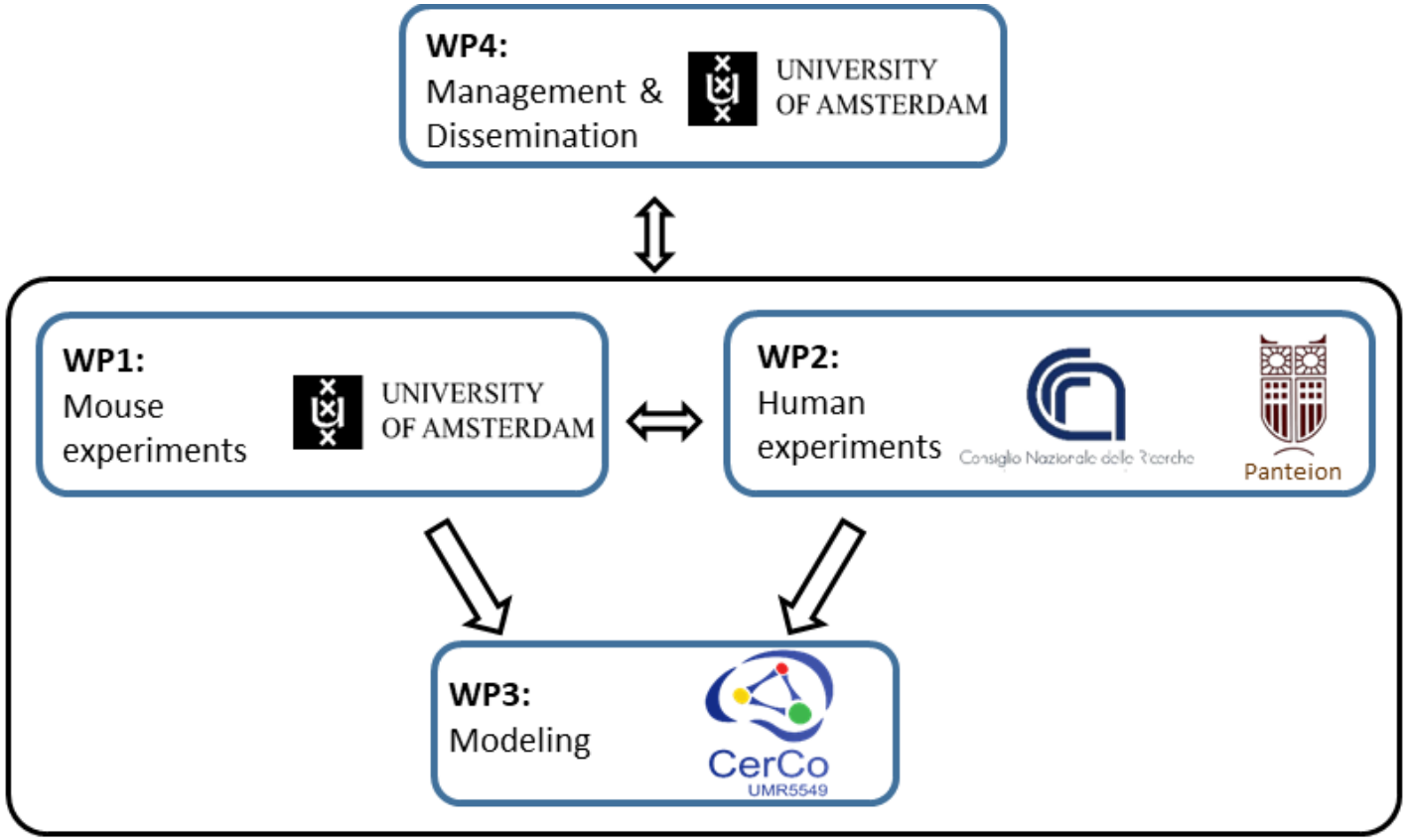


Human experiments
- EEG and psychophysics experiments
- TD and ASD subjects
- From childhood to adulthood

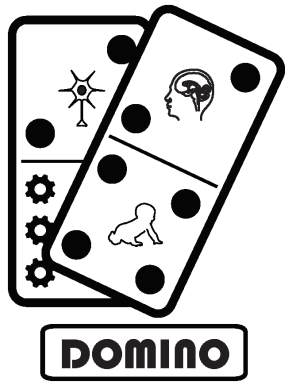


Modeling experiments
- Spiking neural networks with biologically plausible plasticity
- A model of MI development

Project structure and interactions with HBP/EBRAINS



Our team



Project Coordination

WP1: Animal experiments

UNIVERSITY OF AMSTERDAM

Umberto OLCESE

Conrado BOSMAN

Luca MONTELISCIANI

WP2: Human experiments

Panteion University

Argiro VATAKIS

Lydia LIAPI

Lefteris ZOGRAFOS

Nikos SMYRNIS

Neny PERVANIDOU

Consiglio Nazionale delle Ricerche

Guido Marco CICCHINI

Maria Concetta MORRONE

David BURR

Alessandro BENEDETTO

WP3: Modeling

CerCo UMR5549

Benoit R COTTEREAU

Salomé BLAIN

Tushar CHAUHAN

Timothée MASQUELIER

Céline CAPPE

Co-funded by the European Union

WP1: Mouse experiments

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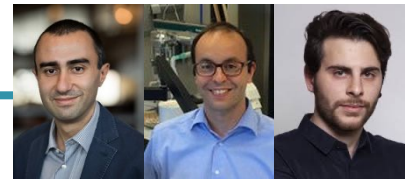

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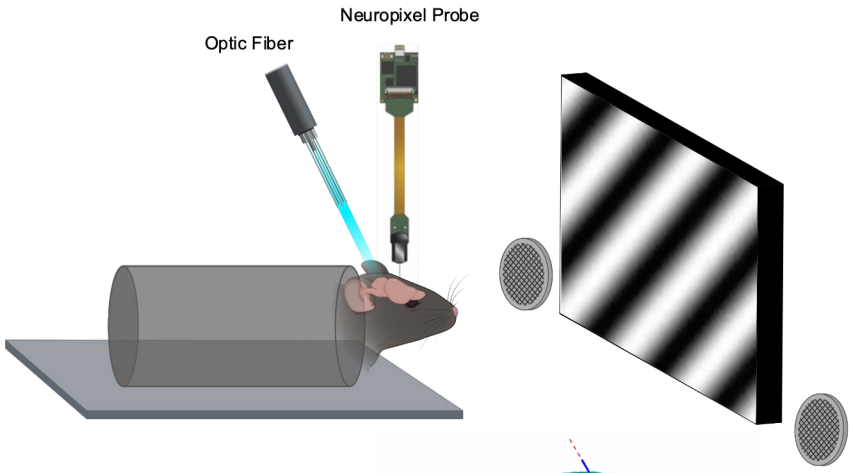
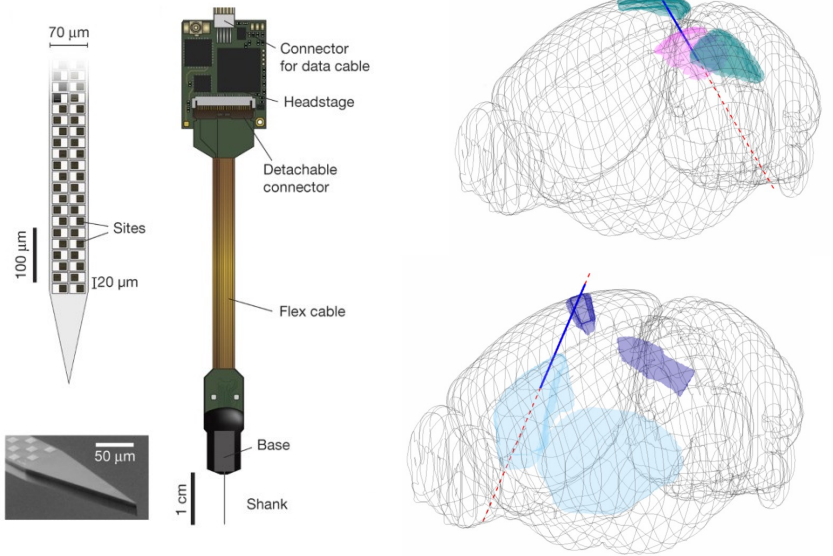
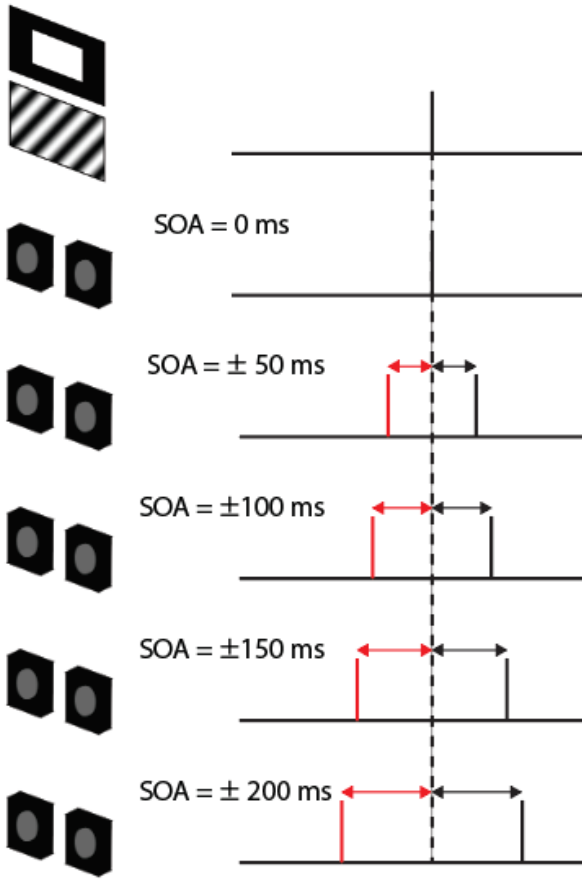
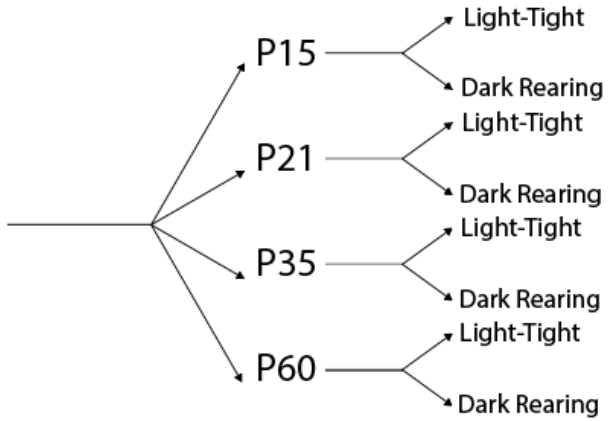






WT PV-Cre
WT VIP-Cre
WT SST-Cre
Fmr1–/– PV-Cre
Fmr1–/– VIP-Cre
Fmr1–/– SST-Cre



WP1: Mouse experiments

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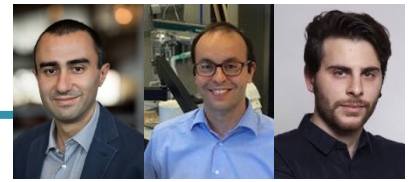

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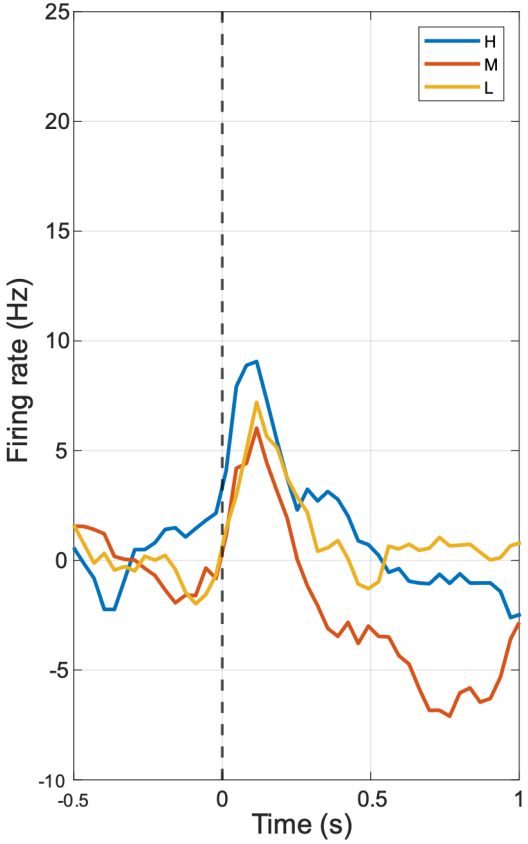
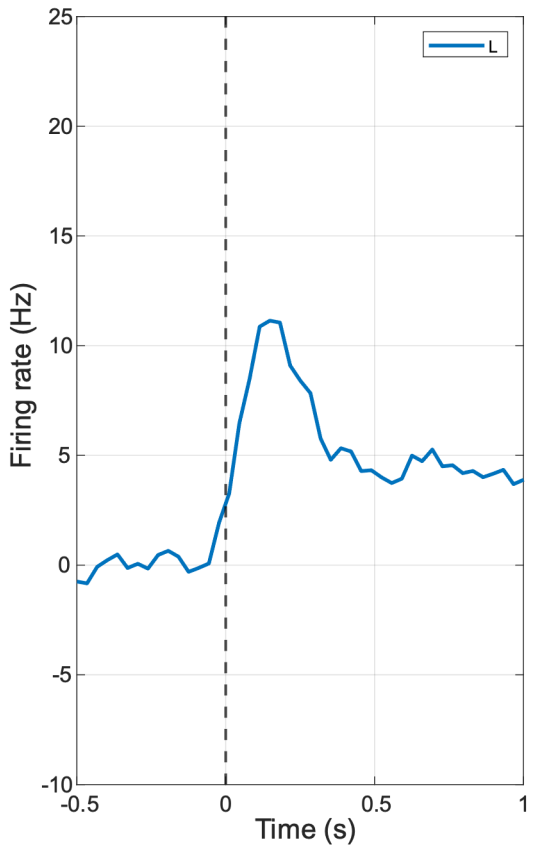
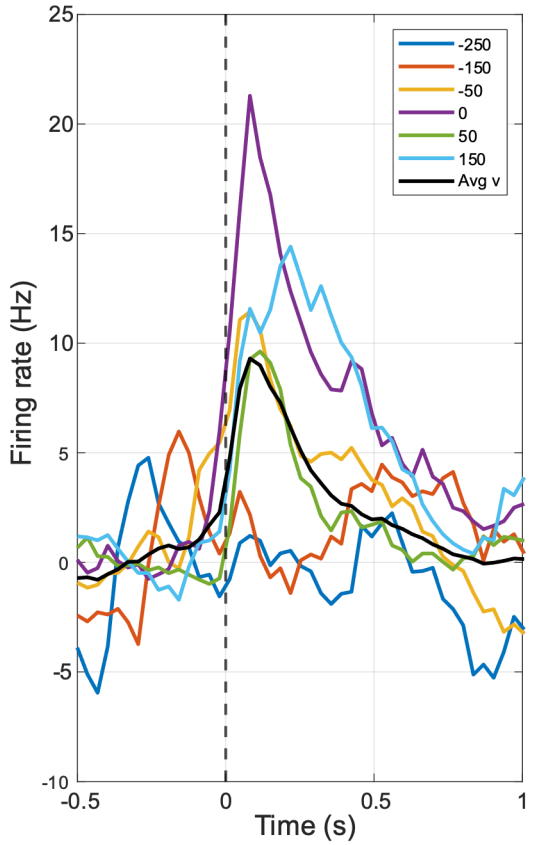


Response to flash (L: low, M: medium, H: high intensity)



Response to sound (white noise)



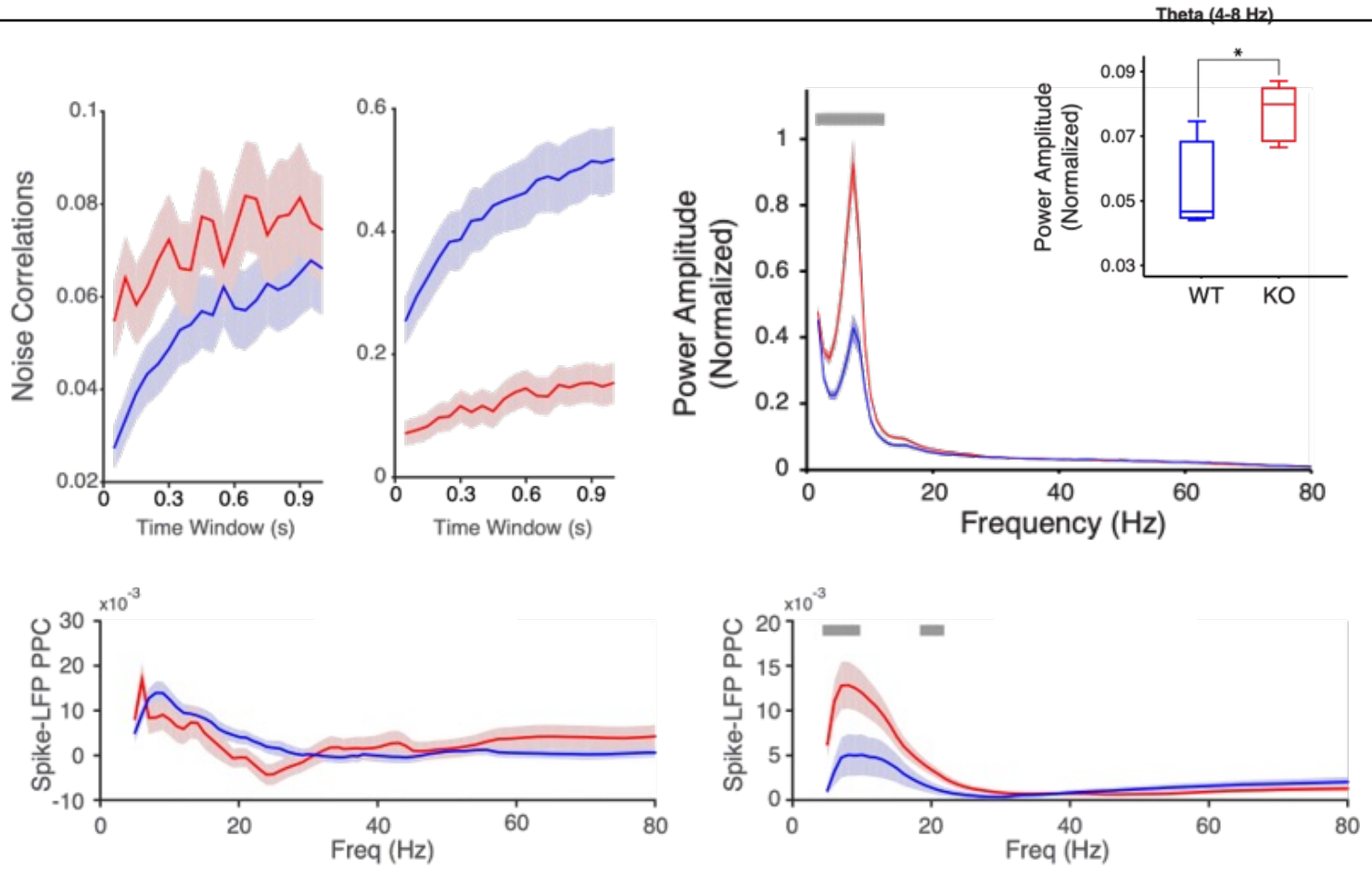
Sound-flash overlap as a function of SOA (in ms, black: visual response)

Example V1 responses

How do the temporal aspects of multisensory integration vary across development and in ASD?

Selection of Frmp-KO mouse as a model of ASD

Abnormal hippocampal hypersyncrony in the Frmp-KO mouse model of FRX



The hypersynchronization of Fmr1-KO oscillations and spike timing might reflect functional deficits in local networks.

Arbab et al. 2018

Is mouse posterior parietal cortex (PPC) involved in perception?

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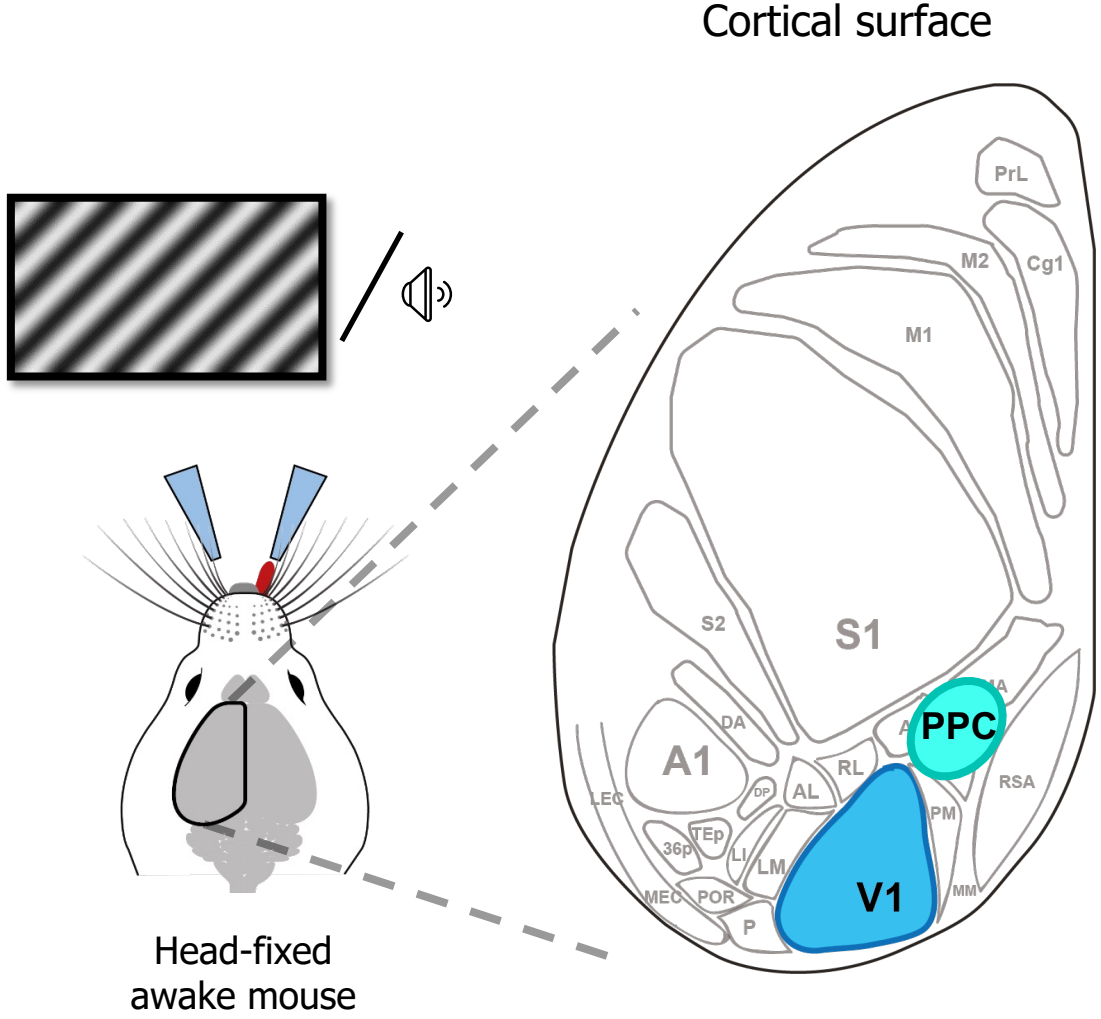
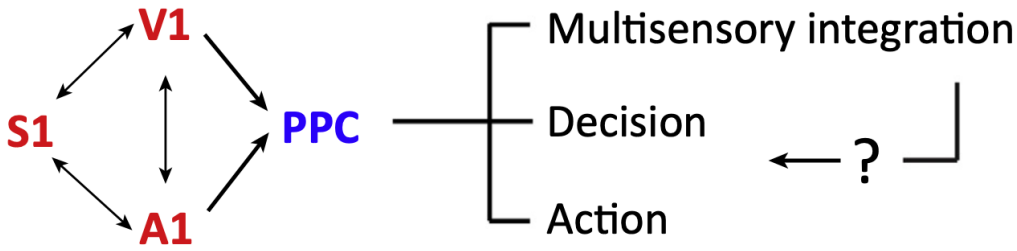
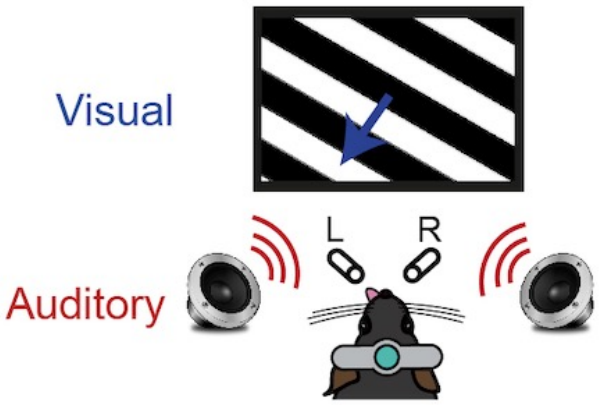
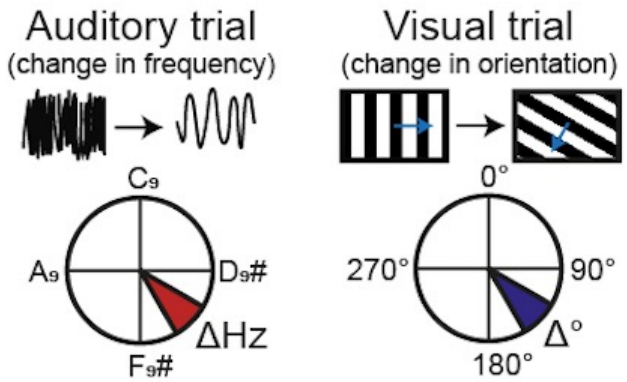


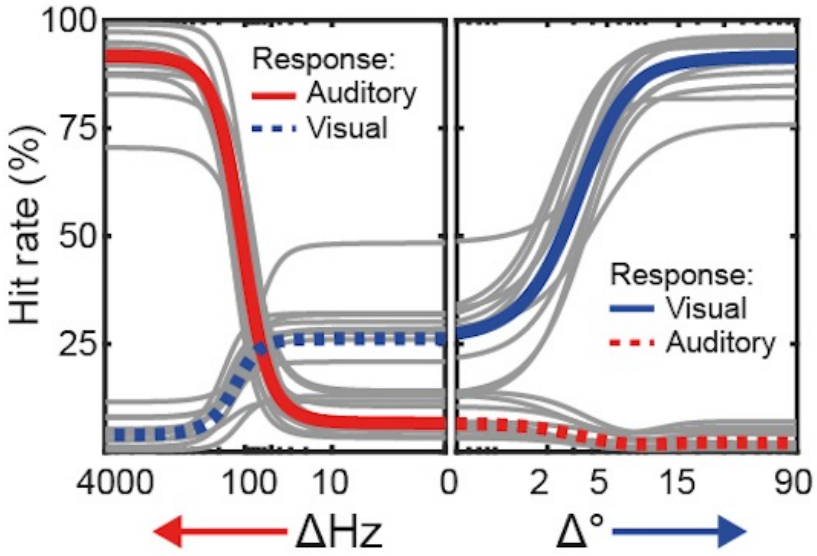


Crochet et al., Trends Neurosci, 2019

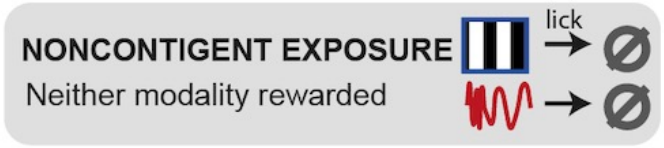
Audio-visual change detection task



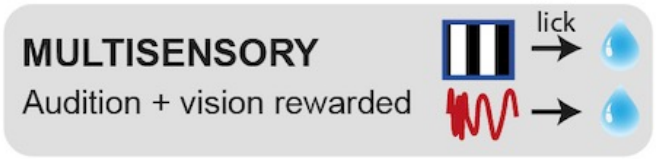




Amount of change (saliency)



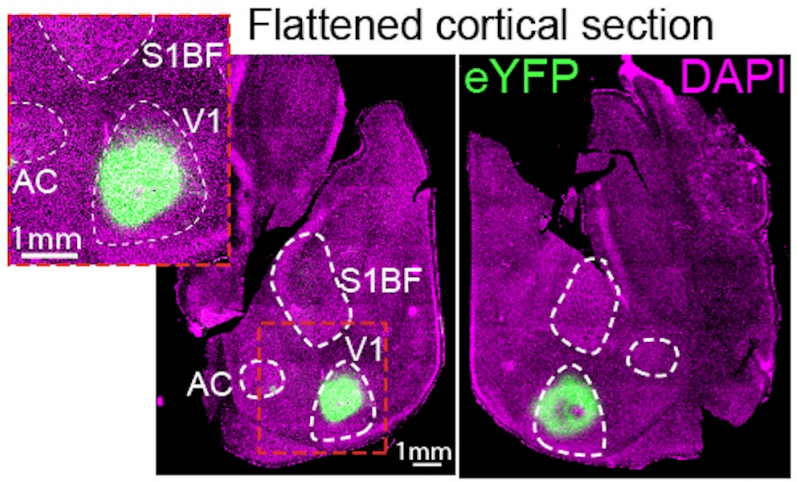
NE cohort (no response)

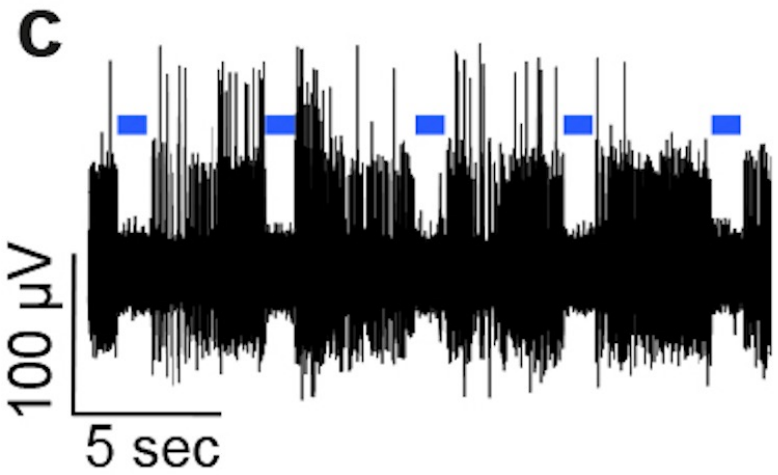


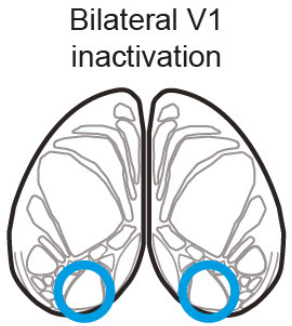
MST cohort

Oude Lohuis et al., Nat. Commun., 2022
Oude Lohuis et al., J Neurosci, 2022

Audio-visual change detection is cortex-dependent







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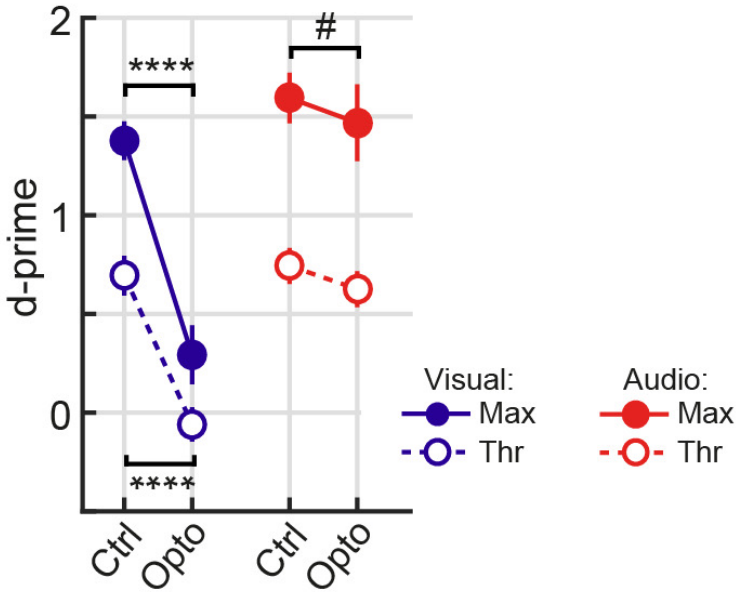
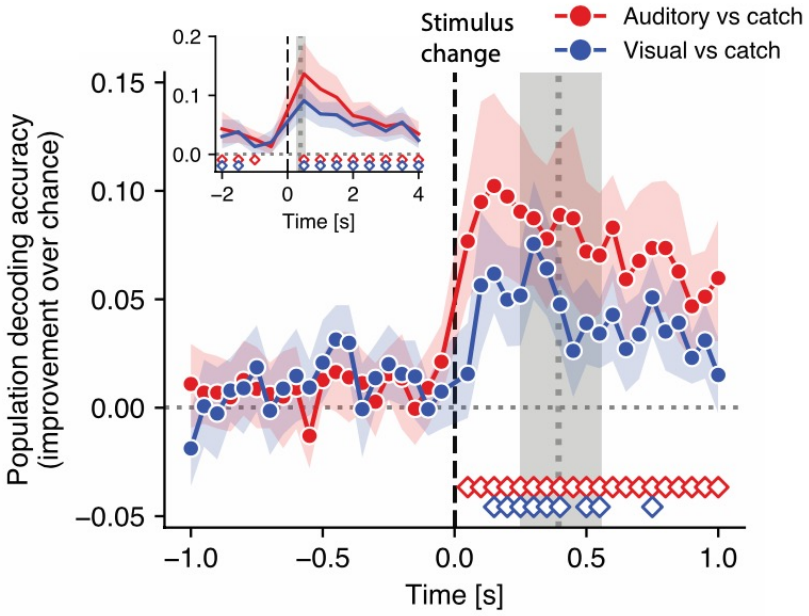
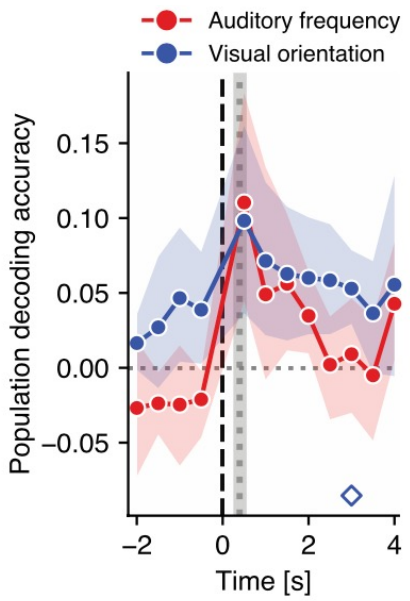
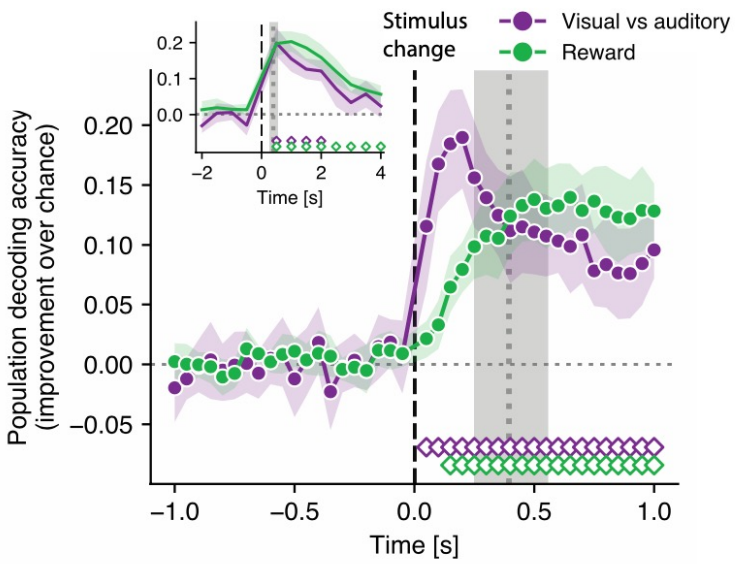


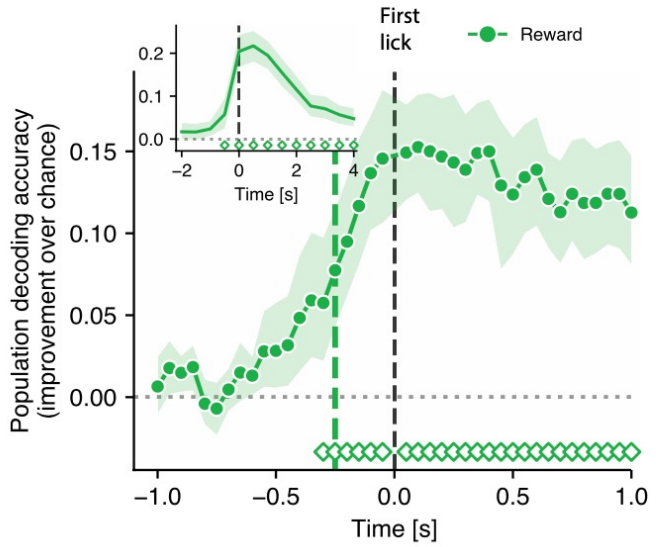
Oude Lohuis et al., Nat. Commun., 2022
Oude Lohuis et al., J Neurosci, 2022

Neural correlates of everything in PPC





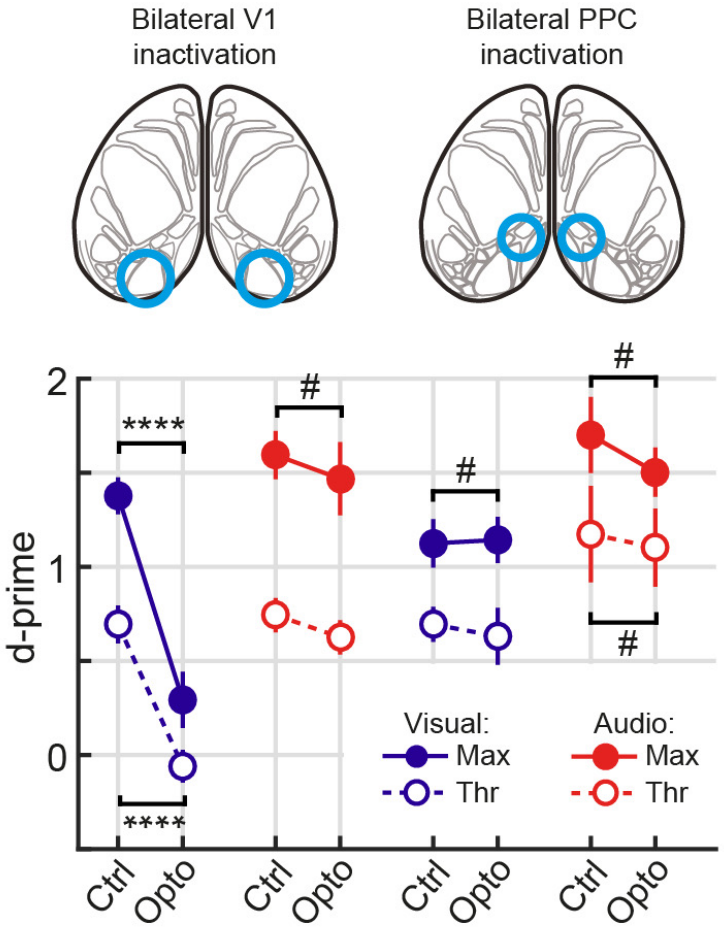


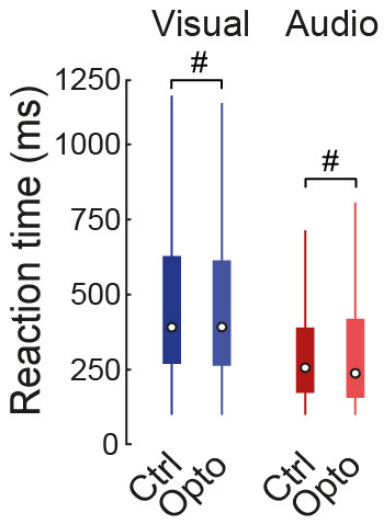


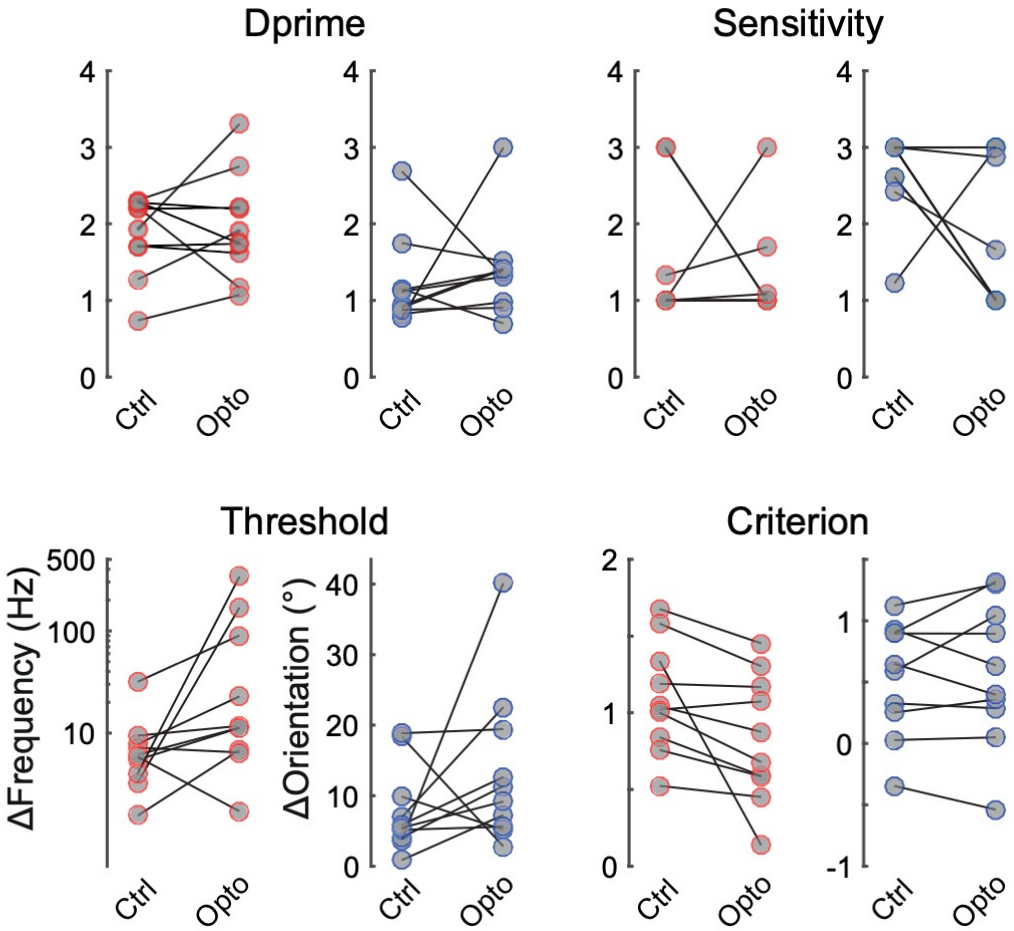
Neuronal activity in PPC reflects sensory information and predicts task performance

Oude Lohuis et al., J. Neurosci., 2022

…but no causal role for anything







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Oude Lohuis et al., J. Neurosci., 2022

Current Activities WP1

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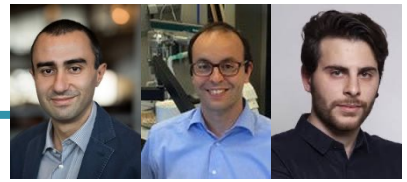
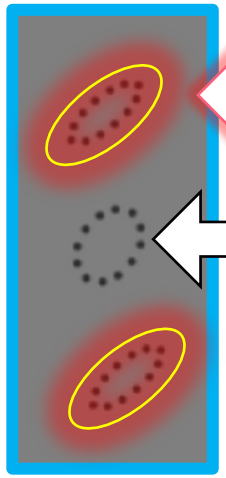
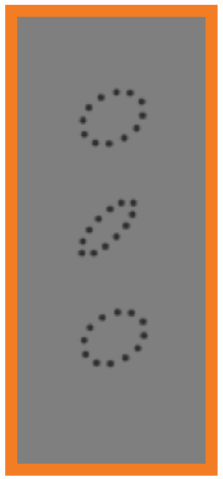


DOMINO

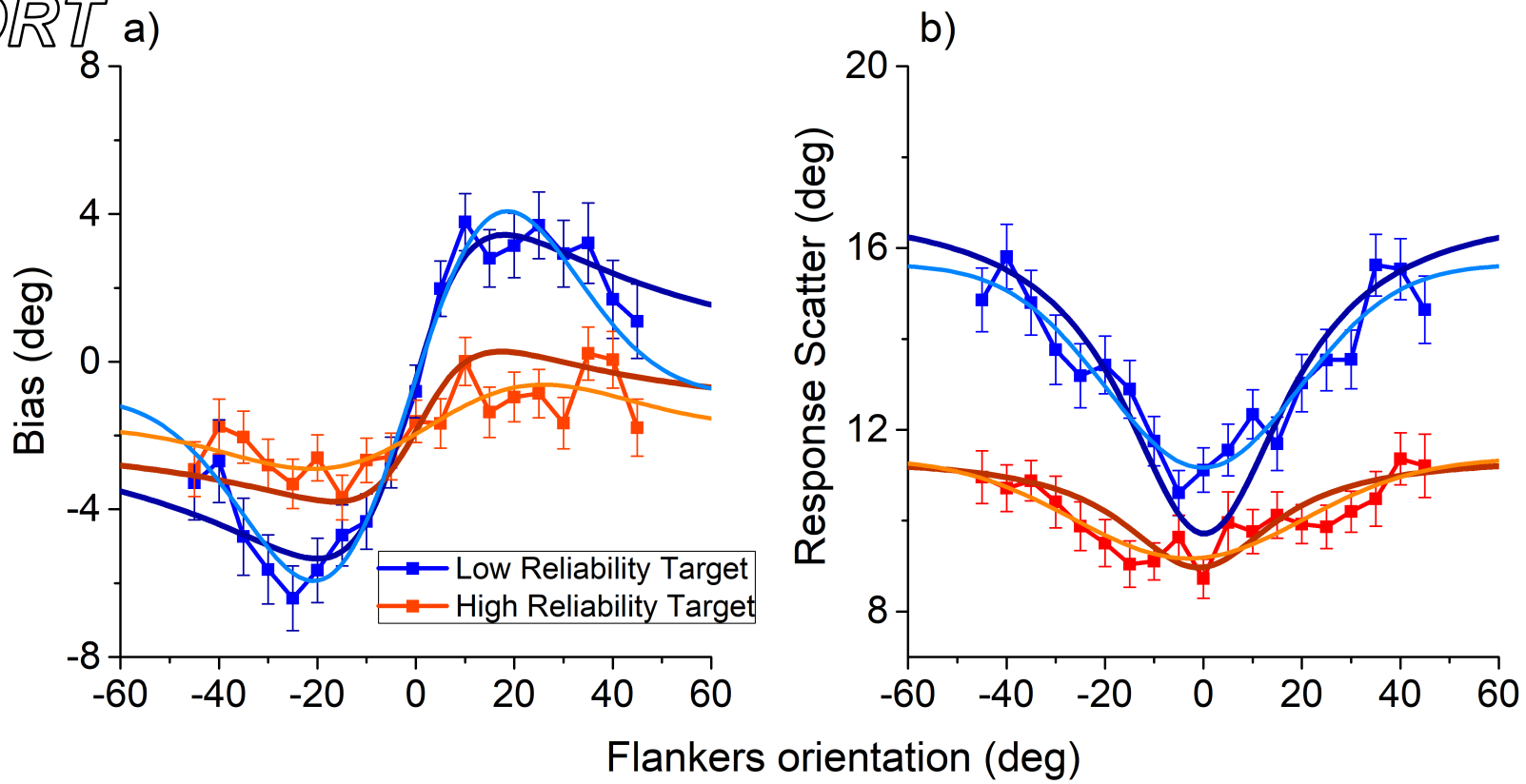
- Data Recording during specific neurodevelopmental milestones
- Comparing with Dark rearing
- Recordings with combined genotypes
- LFP-Spike data analyses (TD mice – Frmp-1 KO)

WP2: Development of MI in TD and ASD individuals

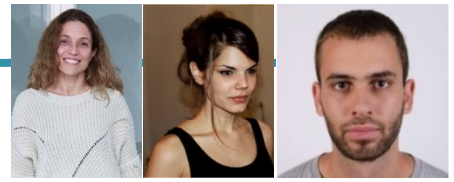




- Aim: Uncover the rules governing data integration in the visual system

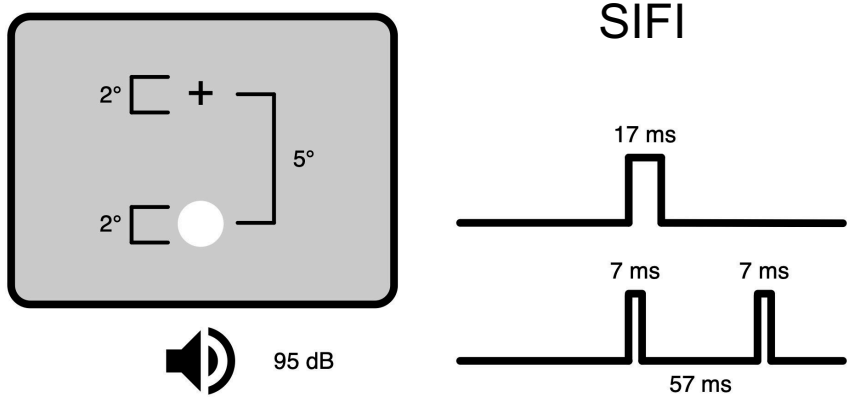


WP2: Development of MI in TD and ASD individuals



DOMINO

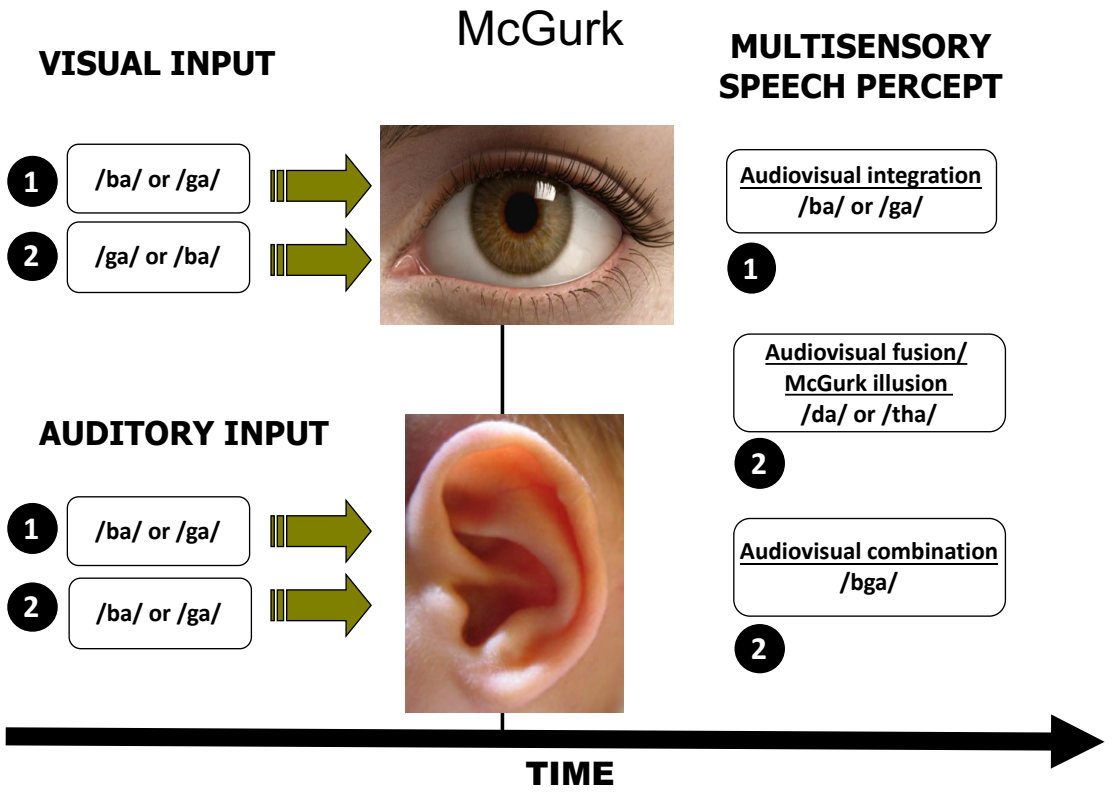
- Aim: Observe how MI processes arise in TD and ASD children and adolescents by combining psychophysics and EEG.



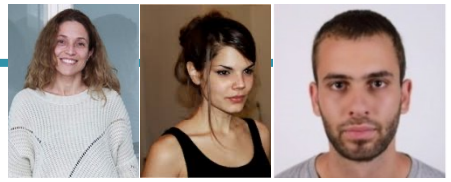
SIFI

Keil, 2020

McGurk



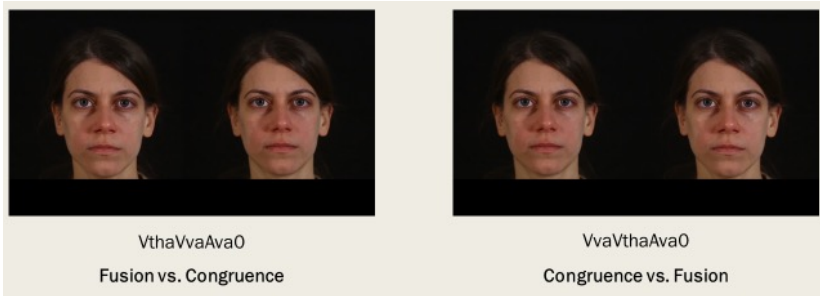
WP2: Development of MI in TD and ASD individuals



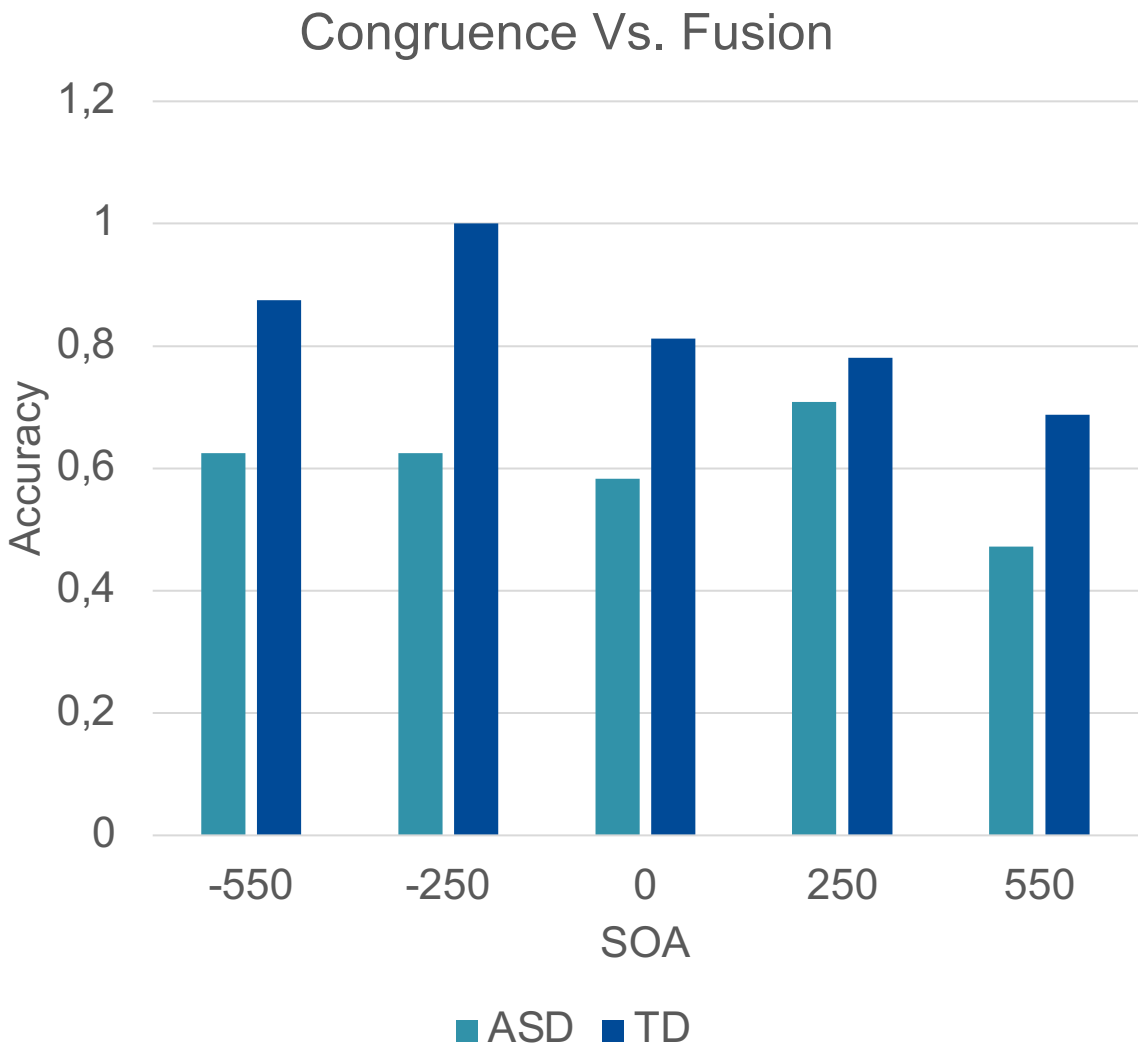
Development of a McGurk task for the Greek language
→ A potential new test for ASD

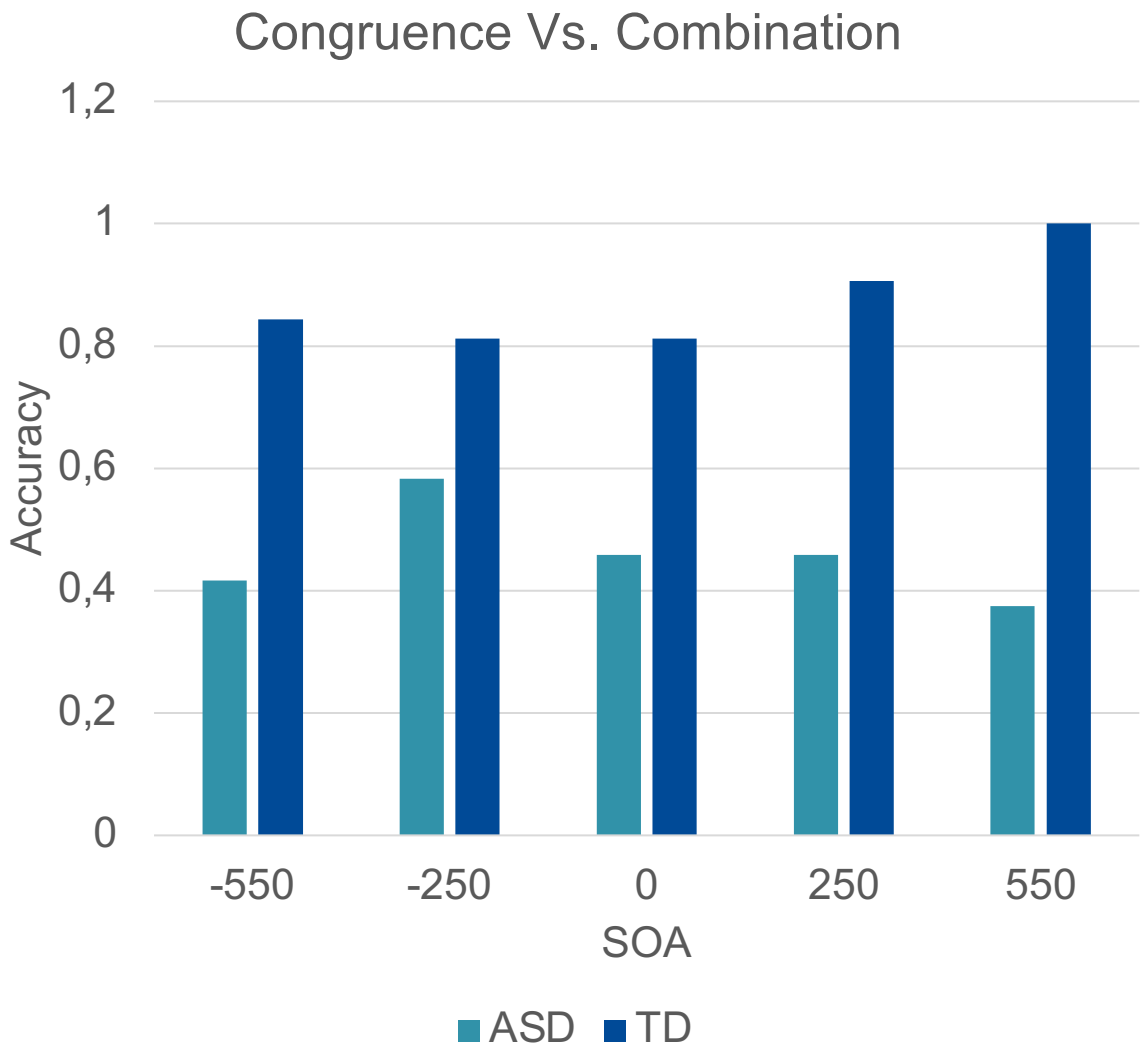
Example tha va AV combinations

- Multiple choice responses
- Response options
  - tha, fa, va, da, ba, ga, nta, pa, ka, other
- N = 90 participants, aged between 13-79 years of age, 88 native Greek speakers
- Significant relationship between stimuli and responses



McGurk preliminary behavioral results





WP2: Current Activities

- Data collection for McGurk & SIFI experiments
- Linguistic aspects of the McGurk effect: aim to explore the influence of place and manner of articulation in the McGurk illusion
- Pairs of mismatching AV components with:
  - the same place and different manner of articulation
  - the same manner and different place of articulation
  - different manner and different place of articulation

Co-funded by the European Union

WP3: Computational model of MI development

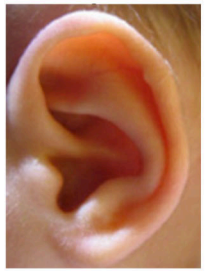
Visual inputs

Auditory inputs

Retina simulator

Spikes

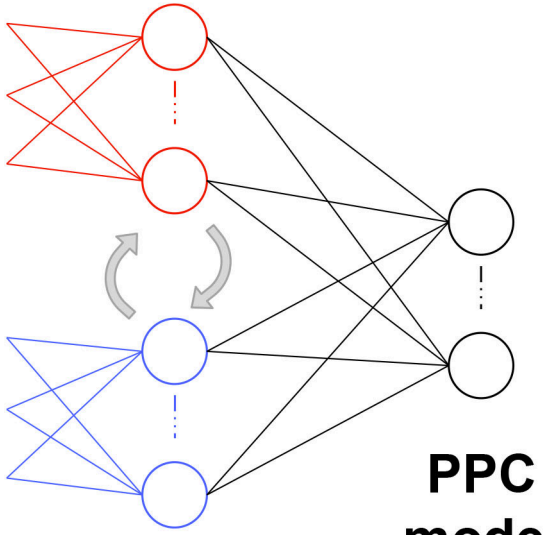
time



Spikes

Cochlea simulator

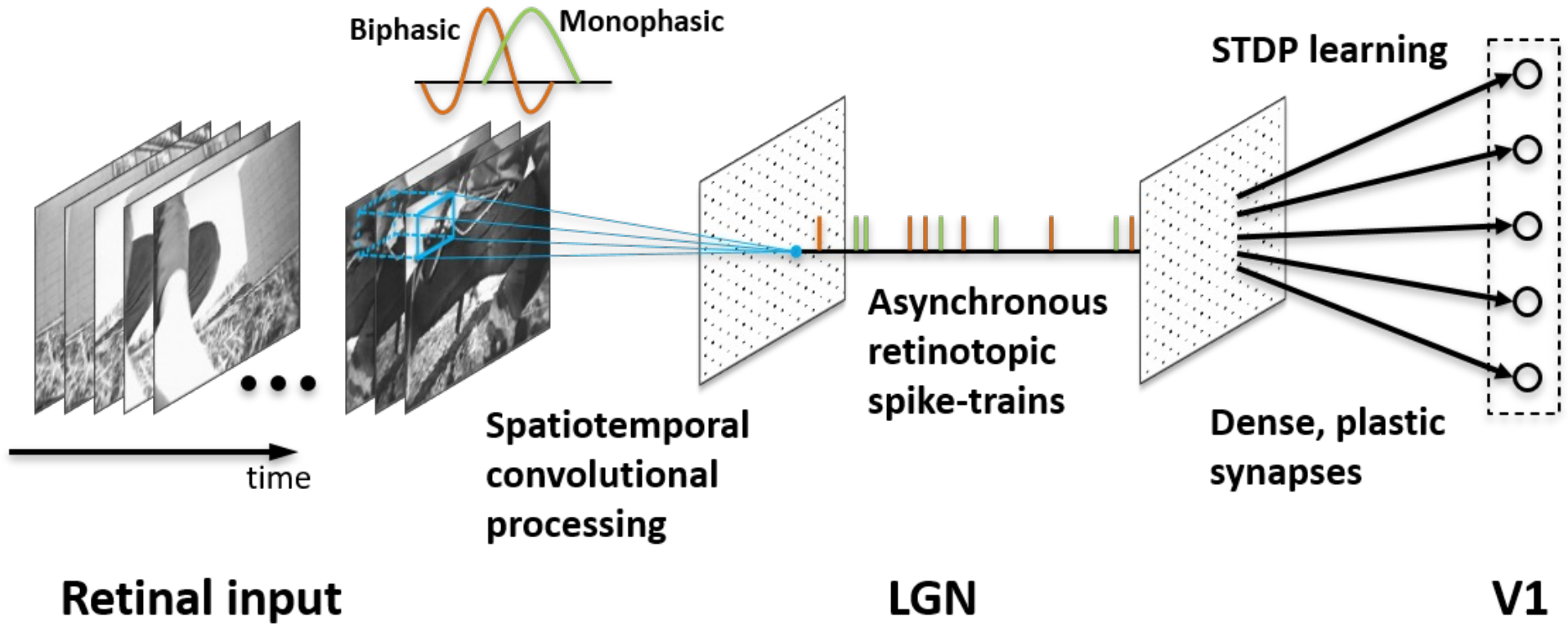
V1 model



PPC model

A1 model

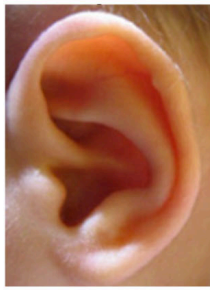
WP3: *Processing dynamics visual stimuli with SNNs*



Motion-direction selective neurons

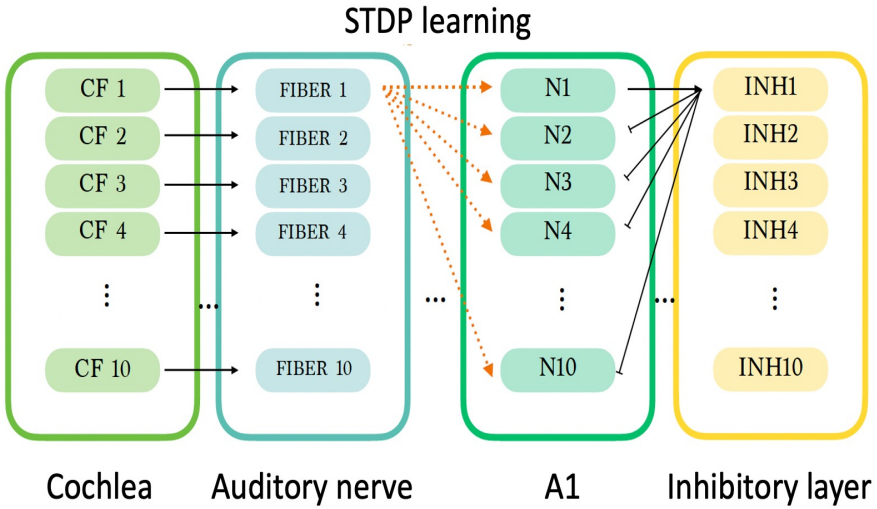
Chauhan et al., J. Neuroscience 2018; Frontiers in Neuroscience 2021

WP3: *Processing realistic auditory stimuli with SNNs*



Audition

Environmental sounds

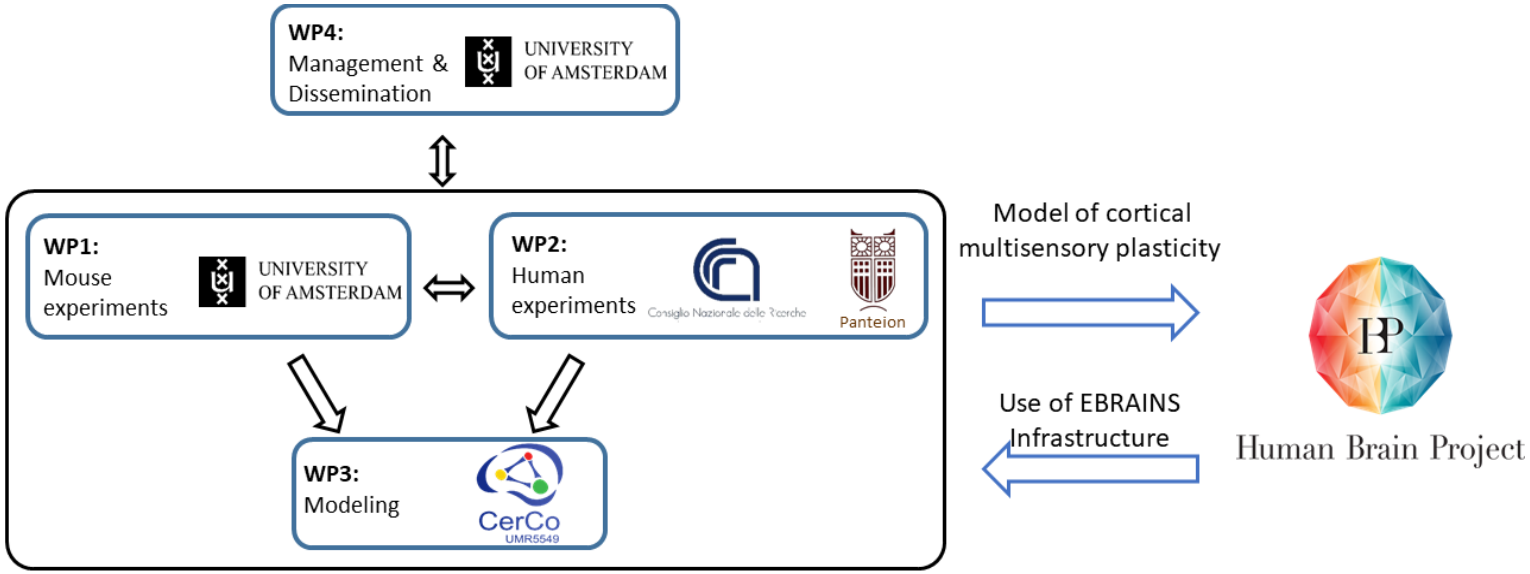


Work under progress…

Frequency selective neurons

Next: *audio-visual integration, normal and abnormal development*

Progress and next steps



Model of cortical multisensory plasticity

Use of EBRAINS Infrastructure

Human Brain Project

	2020		2021				2022				2023			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
WP1: Animal experiments	Preparatory activities			Data collection							Analysis			
WP2: Human Experiments	Preparatory activities				Data collection						Analysis			
WP3: Modeling	Visual model				Auditory model						Audiovisual model			

Co-funded by the European Union

Future Developments using EBRAINS

- Data sharing and curation
- Implementation of Large Scale Models
- Data Integration (mouse – human)

Human Brain Project

EBRAINS

Thank you!

www.humanbrainproject.eu

www.ebrains.eu

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