



# **Alpine Brain Imaging Meeting**

Champéry, Switzerland, January 12-16, 2020

**P R O G R A M**



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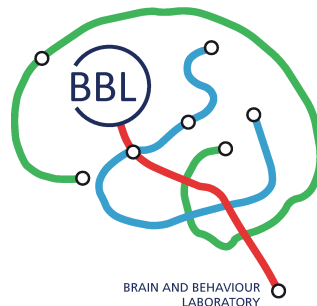


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*ABIM cover from Frédéric Grouiller, photo taken at ABIM 2019.*

# Alpine Brain Imaging Meeting

Champéry 2020

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## Locations:

The opening keynote lecture on Sunday will be held at the *Centre Paroissial et Culturel*. The welcome reception and registration on Sunday will be held at the *Hotel Suisse*. Talks and poster sessions during the week will take place at the *Palladium Sport and Conference Center* (see map for details).

For more information, see website: <http://www.unige.ch/ABIM/>



## **GENERAL INFORMATION**

**Registration** will take place at the *Hotel Suisse* (Rue du Village, 55) on Sunday, the 12<sup>th</sup> of January from 18:30 to 20:30, and will be accompanied by an informal **welcome reception** with nibbles and wine. During the following days, participants can register in the conference room at the *Palladium* conference center (Route du Centre Sportif, 1), only during meeting hours, from 15:15 to 20:00. Additional information can also be obtained at the *Hotel Suisse* outside these hours.

The **opening keynote lecture** (Sunday at 17:30) will be held at the *Centre Paroissial et Culturel* (Route des Dents Blanches, 28), just next to *Hotel Suisse* (see map). All other **talks** and **poster sessions** during the week will take place at the *Palladium* conference center (see program). Posters should be exposed throughout the conference from Monday to Wednesday to allow sufficient viewing time for all participants. Two poster sessions will be held on Tuesday 13<sup>th</sup> (odd numbers) and Wednesday 14<sup>th</sup> of January (even numbers) in the afternoon. Speakers are invited to check their presentation in the conference room no later than at 15:00 on the day of their lecture.

Free **internet access** by WiFi is available in the lounge and in the café of the *Hotel Suisse*, as well as in the *Palladium* conference room (details for the *Palladium* : Réseau = « Wifi\_Partenaire », Login = ABIM, Password = 2020).

There are several **restaurants** in Champéry, including one at the *Palladium* (which is open all day including evenings). Since many restaurants in town are relatively small, you are encouraged to book a table in advance, especially if you go with a large group. The staff at the *Hotel Suisse* or at the *Palladium* can help you with this. The kitchen closes generally around 21.30.

Several **social events** are organized in the evenings during the week and will represent the best occasion to meet among conference participants. Details and updates will be given during the conference: stay tuned!

A special **farewell dinner with celebration of the 15<sup>th</sup> anniversary** is planned on Thursday night at the restaurant *Croix de Culet* (Route de Planachaux, 160, reachable by cable car). A special cable car that will take us to the restaurant on top of the mountain is booked for all of us at **7pm** (please be there on time, multiple rides won't be possible).

The registration for this event will take place during the conference registration. The dinner will be free for all registered participants, excluding beverages. Please refer to the staff at the registration desk before Tuesday January 13th for any changes regarding your participation to the dinner. A **prize ceremony** will be held with best poster and best presentation awards. In case of impossibility to go up with the cable car due to weather conditions we will let you know the alternative plan during the conference.

A **disco party** will follow at the bar *La Crevasse* (Rue du Village, 71), back at the village. Don't miss it!

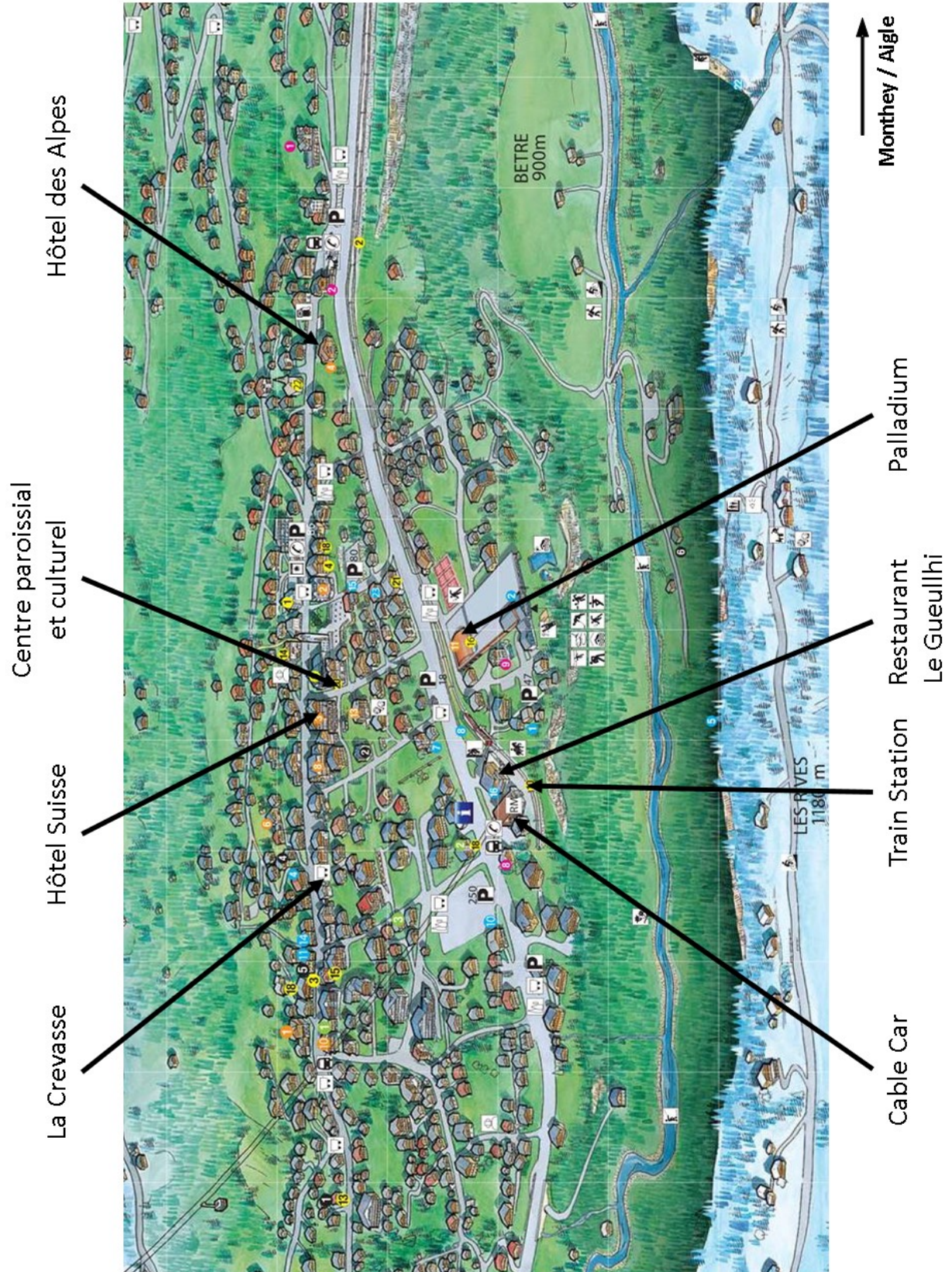
**Ski slopes** can be reached from two places, either using the cable car leaving from Champéry or the chairlift leaving from the Grand-Paradis (see map). Ski-passes of four days can be bought at the *Hotel Suisse* with a group discount (announced during registration on Sunday evening) or individually at the cable car departure. Public buses are available for going to or coming back from the Grand-Paradis.

A **swimming pool** and **skating arena** can also be found in the *Palladium*. The Youth Olympic Games 2020 will take place in the skating arena during the time of the conference!

The abstracts of the talks are listed in this book in order of appearance. A ★ marks presentations from invited speakers. Poster abstracts are ordered according to their topics.

**More information is available on <http://www.unige.ch/ABIM/>**

# MAP





## PROGRAM OVERVIEW

SUNDAY, January 12

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### OPENING LECTURE

**17:30** ▶ **Opening Keynote Lecture** (Centre Paroissial et Culturel)

**David POEPPEL** | *Max Planck Institute for Empirical Aesthetics, Frankfurt, Germany*

**18:30-20:30** ▶ **Welcome Reception & Registration** (Hotel Suisse)

MONDAY, January 13

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### BRAIN MECHANISMS OF DECISION MAKING

**15:30** ▶ **Michael FRANK** | *Brown University, Providence, USA*

- *Corticostriatal dopamine computations in learning and choice*

**16:15** **Mael LEBRETON** | *University of Geneva, Switzerland*

- *Learning what makes a good offer: a neuro-computational account*

**16:35** **Lia ANTICO** | *University of Geneva, Switzerland*

- *Beyond Unpleasantness. Social exclusion affects the experience of pain, but not of comparably-unpleasant disgust*

**16:55** **Coffee Break**

**17:30** ▶ **Christelle BAUNEZ** | *Institut de Neurosciences de la Timone, Marseille, France*

- *The subthalamic nucleus: a critical node for decision-making*

**18:15** **Michael PEREIRA** | *Université Grenoble Alpes, France & Swiss Federal Institute of Technology (EPFL), Geneva, Switzerland*

- *Subthalamic nucleus activity reflects first and second-order conscious reports*

**18:35** **Hal BLUMENFELD** | *Yale University School of Medicine, New Haven, USA*

- *Neuroimaging and Electrophysiology in Large Data Sets Reveal Neural Sequence of Human Conscious Perception: Detect, Pulse, Switch and Wave*

18:55 **Nicolas ROEHRI** | *Institut de Neurosciences des Systèmes, Marseille, France*

- *Hippocampal-thalamo-cortical coupling between ripples, spindles and slow oscillations during NREM sleep in human: a SEEG study*

## TUESDAY, January 14

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### MEMORY AND PLASTICITY

15:30 **Peggy ST.JACQUES** | *University of Alberta, Edmonton, Canada*

- *The flexible nature of visual perspective in memories for events*

16:15 **Roland BENOIT** | *Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany*

- *Revealing the structure of affective schematic representations in the medial prefrontal cortex*

16:35 **Blanca MARIN BOSCH** | *University of Geneva, Switzerland*

- *Acute physical exercise rescues entorhinal spatial coding in young APOE carriers - preliminary results*

16:55 **Coffee Break**

17:30 **Tamar MAKIN** | *UCL, London, UK*

- *Homo Cyberneticus: Neurocognitive considerations for the embodiment of artificial limbs.*

18:15-20:00 **Poster Session** with drinks and snacks

## WEDNESDAY, January 15

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### THE VALUE OF ULTRA-HIGH-FIELD MRI

15:30 **Peter BANDETTINI** | *Center for Multimodal Neuroimaging, NIMH, Bethesda, USA*

- *New Maps of Activation, Connectivity, and Hierarchy using Ultra-high resolution fMRI and endogenous blood volume contrast*

16:15 **Jonathan WIRSICH** | *University Hospitals and Faculty of Medicine of Geneva, Switzerland*

- *EEG and fMRI connectomes are reliably related: a concurrent EEG-fMRI study from 1.5T to 7T*

16:35 **Silvia MARCHESOTTI** | *University of Geneva, Switzerland*

- *Non-invasive brain stimulation transiently reinstates low gamma sampling and boost phonological processing in adults with dyslexia*

16:55 **Coffee Break**

17:30 **Lars MUCKLI** | *Centre for Cognitive Neuroimaging, Glasgow, UK*

- *Visual Predictions in different layers of visual cortex*

18:15-20:00 **Poster Session** with drinks and snacks

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## THURSDAY, January 16

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### BRAIN IMAGING ACROSS LIFESPAN

15:30 **Ulman LINDENBERGER** | *Max Planck Institute for Human Development, Berlin, Germany*

- *Human Cognitive Aging: Maintenance Versus Dedifferentiation*

16:15 **Smadar OVADIA-CARO** | *University of Haifa, Israel*

- *The impact of ischemic stroke on connectivity gradients*

16:35 **Kristoffer MÅNSSON** | *Karolinska Institutet, Stockholm, Sweden*

- *Moment-to-moment variability in visual cortex robustly predicts anxiety disorder patient responses to psychological treatment*

16:55 **Vanessa SIFFREDI** | *University of Geneva, Switzerland*

- *Structural neuroplastic responses preserve functional connectivity and neurobehavioural outcomes through strengthening of intra-hemispheric pathways in children born without a corpus callosum*

17:15 **Coffee Break**

17:45 **Christian CLOT - 15<sup>TH</sup> ANNIVERSARY SPECIAL KEYNOTE**



- *Why study brain adaptation to change under real life extreme situation?*

19:00 **15<sup>TH</sup> ANNIVERSARY CELEBRATION & FAREWELL PARTY** with prize ceremony

- *Dinner at the Restaurant Croix de Culet (cable car at 19:00)*
- *Disco party at the bar La Crevasse*



# **ABSTRACTS OF ORAL PRESENTATIONS**

The themes of the days are:

Sunday: **OPENING LECTURE**

Monday: **BRAIN MECHANISMS OF DECISION MAKING**

Tuesday: **PLASTICITY AND AGING**

Wednesday: **ULTRA-HIGH FIELD fMRI**

Thursday: **MEMORY AND LEARNING**

The abstracts of the talks are listed in this book in order of appearance.

A ★ marks presentations from invited speakers.

*Sunday*

## **Opening Lecture**

**T1** ★

David Poeppel<sup>1</sup>

<sup>1</sup>Max Planck Institute for Empirical Aesthetics, Frankfurt, Germany

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To be announced.

*Monday*

## **Brain Mechanisms of Decision Making**

**T2** ★

### **Corticostriatal dopamine computations in learning and choice**

Michael Frank<sup>1</sup>

<sup>1</sup>Brown University, Providence, USA

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The basal ganglia and dopaminergic systems are well studied for their roles in reinforcement learning and reward-based decision making. Much work focuses on "reward prediction error" (RPE) signals conveyed by dopamine and used for learning. Computational considerations suggest that such signals may be enriched beyond the classical global and scalar RPE computation, to support more structured learning in distinct sub-circuits ("vector RPEs"). Such signals allow an agent to assign credit to the level of action selection most likely responsible for the outcomes, and hence to enhance learning depending on the generative task statistics. I will first describe the computational models spanning levels of analysis from implementation to function. I will then present evidence across species and methods -- from fMRI and EEG in humans to calcium imaging of striatal dopamine terminals in rodents -- that RPE signals are modulated by instrumental task demands, in accordance with vector RPEs.

# Brain Mechanisms of Decision Making

## T3

### **Learning what makes a good offer: a neuro-computational account**

Maël Lebreton<sup>1</sup>, Michael Giffin<sup>2</sup>, Andrea Farina<sup>2</sup>, Jorg Gross<sup>2</sup>, Carsten DeDreu<sup>2</sup>

<sup>1</sup>LabNic & CISA, University of Geneva, Switzerland, <sup>2</sup>Leiden University, Netherlands

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Market inefficiencies emerge because buyers offer more than their seller's threshold (leaving money on the table) or too little (foregoing trade). Trading situations are often ambiguous, because different sellers have different thresholds for the same goods. Understanding how buyers adapt their offer to sellers' thresholds and create efficient trade is therefore crucial. We designed a modified version of the Ultimatum Game: proposers (viz. buyers) were repeatedly matched with responders (viz. sellers) drawn from three different populations characterized by different probabilistic acceptance thresholds. In a Social condition, proposers dealt with actual responders, such that the deal outcome affected both parties' payoffs. In a Non-Social condition, proposers dealt with computer-generated lotteries mimicking the behavior of human responders, such that the deal outcome only affected the proposers' payoffs. We found that proposers learn to adapt their offer to the different populations' thresholds – a process efficiently captured by a novel reinforcement-learning algorithm. Model-based fMRI mapped these learning operations in canonical reinforcement learning neural circuitry (ventral striatum, VMPFC). Our results also show that learning occurred faster in the non-social than in the social condition, indicating that social concern about the receiver's payoff might harm efficient learning. Model-based fMRI mapped this effect in the dACC and the STS - regions associated with conflict monitoring, and social cognition/ theory of mind. Altogether, our results shed new lights on the subtle balance between learning to trade efficiency, which aims to maximize one's payoff by identifying the minimally acceptable offer, and social preferences, which encourage proposing fair offers.

# Brain Mechanisms of Decision Making

## T4

### **Beyond Unpleasantness. Social exclusion affects the experience of pain, but not of comparably-unpleasant disgust**

Lia Antico<sup>1,2</sup>, Charlotte Reguidiere<sup>1</sup>, Ander Baranda Urquijo<sup>2</sup>, Asli Erdemli<sup>2</sup>, Laura Riontino<sup>1</sup>, Corrado Corradi-Dell'Acqua<sup>1</sup>

<sup>1</sup>Theory of Pain Laboratory, Department of Psychology, Faculty of Psychology and Educational Sciences, University of Geneva, Geneva, Switzerland, <sup>2</sup>Swiss Center for Affective Sciences, University of Geneva, Geneva, Switzerland

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Seminal theories suggest that social rejection and physical pain underlie partly common representational code. Indeed, exclusion can influence the subjective experience of subsequent painful stimuli. Furthermore, social and physical pain have been associated with a partly-overlapping neural activations at the level of secondary somatosensory cortex, dorsal cingulate cortex and anterior insula. It is unclear, however, whether these effects underlie a modality-specific component of pain, or rather a supra-modal representation reflecting properties common to other unpleasant experiences, even painless. To address this question we engaged neurotypical volunteers in a virtual ball-tossing game with virtual players who either interacted with the participant (inclusion condition), or ignored him/her (exclusion condition). After each game interaction, we delivered painful (thermal) or disgusting (gustatory) stimuli carefully matched for subjective unpleasantness. We found converging evidence of reduced sensitivity to pain following exclusion (as opposed to inclusion), as revealed by the analysis of both subjective ratings and physiological responses. Crucially, these effects were not observed for the response to disgust, who was unaffected by the gaming manipulation. Neuroimaging data underline consistently differential interplays between social exclusion and experiences of pain and disgust. Importantly, we found a reduced activation of the neural network of pain perception, especially at the level of insula, during painful stimulation following exclusion (as opposed to inclusion). Overall, these findings indicate that the relationship between social exclusion and physical pain is modality-specific and does not generalize to disgust.

# Brain Mechanisms of Decision Making

**T5** ★

## **The subthalamic nucleus: a critical node for decision-making**

Christelle Baunez<sup>1</sup>

<sup>1</sup>Institut de Neurosciences de la Timone, UMR7289 CNRS & Aix-Marseille Université, Marseille, France

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The subthalamic nucleus has been associated with motor functions for a long time. It has however revealed a critical role in frontal functions such as attention, control of inhibition, motivation and emotions. The presentation will focus on the involvement of STN in decision-making processes. The effects of STN manipulations (lesions, pharmacological inactivation, deep brain stimulation or optogenetic activation or inhibition) in rats, monkeys or human patients suffering from Parkinson's Disease, Obsessive Compulsive Disorders or addiction will be reviewed, as well as electrophysiological recordings of STN activity during performance of reward-related tasks involving decision making.



# Brain Mechanisms of Decision Making

## T6

### **Subthalamic nucleus activity reflects first and second-order conscious reports**

Nathan Faivre<sup>1, 2</sup>, Michael Pereira<sup>1, 2</sup>, Fosco Bernasconi<sup>2</sup>, Jacob Suffridge<sup>3</sup>, Shuo Wang<sup>3</sup>, Victor Finomore<sup>3</sup>, Nicholas Brandmeir<sup>3</sup>, Ali Rezai<sup>3</sup>, Olaf Blanke<sup>2</sup>

<sup>1</sup>Laboratoire de Psychologie et Neurocognition (LPNC), CNRS UMR 5105, Université Grenoble Alpes, France, <sup>2</sup>Laboratory of Cognitive Neuroscience, Brain Mind Institute, Faculty of Life Sciences, Swiss Federal Institute of Technology (EPFL), Geneva, Switzerland, <sup>3</sup>Rockefeller Neuroscience Institute (RNI), West Virginia University, Morgantown, United States

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Perceptual consciousness encompasses two interrelated phenomena: the subjective experience associated with a sensory event, and the reflexive monitoring of the corresponding percept which involves a second-order representation of a stimulus. The study of first and second-order consciousness is now based on empirical yet mostly distinct grounds. A way to simultaneously characterize first and second-order consciousness is to ask volunteers to detect stimuli presented around the threshold for detectability and to provide subsequent confidence ratings about the likelihood that they correctly detected the stimulus. We used this paradigm in neurological patients undergoing surgery for deep brain stimulation. Our results show that single-unit activity in the subthalamic nucleus reflects both detection and confidence reports, suggesting the existence of subcortical correlates of first and second-order consciousness.

# Brain Mechanisms of Decision Making

## T7

### **Neuroimaging and Electrophysiology in Large Data Sets Reveal Neural Sequence of Human Conscious Perception: Detect, Pulse, Switch and Wave**

Hal Blumenfeld<sup>1</sup>, Kate Christison-Lagay<sup>1</sup>, Sharif Kronemer<sup>1</sup>, Hunki Kwan<sup>1</sup>, Aya Khalaf<sup>1</sup>, Rong Li<sup>1</sup>, Mariana de Mello Gusso<sup>1</sup>, Kevin Wang<sup>1</sup>, Desiree Wong<sup>1</sup>, Lauren Kim<sup>1</sup>, Matthew Peoples<sup>1</sup>, Claire Hu<sup>1</sup>, Christopher Micek<sup>1</sup>, Noah Freedman<sup>1</sup>, Julia Ding<sup>1</sup>, Mark Aksen<sup>1</sup>, Peter Vincent<sup>1</sup>, Jun Hwan Ryu<sup>1</sup>, Jason Gerrard<sup>1</sup>, Eyiymisi and Dennis Damisah and Spencer<sup>1</sup>

<sup>1</sup>Departments of Neurology, Neuroscience and Neurosurgery, Yale University School of Medicine, New Haven, CT USA

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Recent human neuroimaging and direct cortical electrophysiology has shed significant light on mechanisms of conscious perception. Using visual detection tasks and intracranial electroencephalography (icEEG) we found a widespread wave of broadband gamma activity in association cortices, and a switch off of default mode and early detection networks (W. Herman et al. 2019, Cerebral Cortex; J. Li et al. 2019, Neuroimage). We now investigate: 1. Fast signals in stimulus detection; 2. Subcortical-cortical amplification networks; 3. Generalizability of findings beyond vision. To study detection we analyzed large multi-center data sets of icEEG. This revealed a detection network with broadband gamma increases <150ms after stimulus onset in visual association cortex, frontal eye fields, intraparietal sulcus, orbital and frontopolar cortices. To investigate subcortical-cortical amplification, we used fMRI during three different visual detection tasks. We found a novel early transient pulse of fMRI increases in subcortical midbrain, thalamus, striatum and cortical salience networks, as well as later expected signals in dorsal attention and default mode networks. Finally, to determine generalizability of findings we studied an auditory detection task with icEEG (n=25 subjects, 2154 electrodes). This revealed a wave of broadband gamma in association cortex and switch off in default mode networks very similar to visual perception. In summary, we propose that conscious perception depends on the following sequence of neural events: 1. Detect in primary and higher association cortex; 2. Pulse of subcortical-cortical amplification; 3. Switch off of default mode and other competing networks; 4. Wave of processing in hierarchical association cortex and memory regions.

# Brain Mechanisms of Decision Making

## T8

### **Hippocampal-thalamo-cortical coupling between ripples, spindles and slow oscillations during NREM sleep in human: a SEEG study**

Nicolas Roehri<sup>1</sup>, Christian-George Bénar<sup>1</sup>, Francesca Pizzo<sup>1, 2</sup>, Stanislas Lagarde<sup>1, 2</sup>, Bernard Giusiano<sup>1, 3</sup>, Fabrice Bartolomei<sup>1, 2</sup>, Isabelle Lambert<sup>1</sup>

<sup>1</sup>Aix Marseille Univ, Inserm, INS, Institut de Neurosciences des Systèmes, Marseille, France, <sup>2</sup>APHM, Timone Hospital, Clinical Neurophysiology, Marseille, France, <sup>3</sup>APHM, Public Health Department, Marseille, France

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According to the Active System Consolidation Model, information is progressively transferred from hippocampus to neocortex during NREM sleep. This hippocampal-neocortical dialogue is mediated by the coupling between cortical slow waves, thalamo-cortical spindles and hippocampal ripples. Few studies have investigated this coupling in humans. We aim to study the interaction of these oscillations between and within the hippocampus, thalamus and neocortex using intracranial recordings. We included eight patients who underwent intracranial recording for presurgical investigation of drug-resistant epilepsy. Inclusion criteria were: 1) electrode implantation including ipsilateral hippocampus, thalamus and middle frontal gyrus, 2) recording of NREM sleep and 3) few epileptic spikes (<15 spikes/min). We automatically detected spindles, ripples and spikes in all three regions (Delphos, Roehri et al, 2016). We computed the Inter-trial coherence (ITC) and phase locking value (PLV), and phase-amplitude coupling (PAC), each within and between regions triggered on either spindles or ripples. Group level statistics were corrected with the local FDR procedure. PLV showed a strong coupling between spindles of each region. ITC revealed a local coherence in slow waves (below 1 Hz) during spindles in each region and PLV between thalamus and frontal region. During ripples, ITC showed local delta wave coherence in hippocampus and frontal regions. The PAC analysis highlights the coupling between the spindles in the hippocampus and thalamus with the hippocampal ripples as well as the coupling between frontal slow oscillations and hippocampal spindles. These results are in line with the Active System Consolidation Model while describing new inter and intra-regional aspects.

*Tuesday*

## **Memory and Plasticity**

**T9** ★

### **The flexible nature of visual perspective in memories for events**

Peggy St. Jacques<sup>1</sup>

<sup>1</sup>Department of Psychology, University of Alberta, Edmonton, Canada

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Memories for events, including autobiographical experiences, require adopting a particular visual perspective, or window on which to remember the past. This visual perspective may be centered from one's own eyes or from observer-like vantage points. Previous research has suggested that visual perspective signals mnemonic changes, reflecting the dynamic and flexible nature of our memory system. However, less is known about how visual perspective influences the neural mechanisms that contribute to such modifications in memories. In this talk, I will present recent behavioural and functional neuroimaging data that investigate how manipulating visual perspective during retrieval reshapes memories online and over the longer term.

# Memory and Plasticity

## T10

### **Revealing the structure of affective schematic representations in the medial prefrontal cortex**

Roland Benoit<sup>1</sup>, Ian Charest<sup>2</sup>, Philipp Paulus<sup>1</sup>

<sup>1</sup>Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, <sup>2</sup>School of Psychology, University of Birmingham, UK

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The rostro- and ventromedial prefrontal cortex (mPFC) is involved in valuation and supports memory schemas. Schemas (e.g., of a social network) emerge by extracting commonalities across overlapping experiences and can be understood as network graphs comprising nodes (e.g., individual people) and edges (e.g., their relationships). Here, we propose that the mPFC encodes representations of both the individual nodes and their edges. Specifically, we hypothesize that the strength of the edges is determined by (i) the degree of one's experience with the respective nodes, (ii) their centrality to the schema, and (iii) their affective value. Participants estimated these three features (i.e., experience, centrality, and affective value) of personally familiar people and places. We then extracted a common principal component of the three features that quantifies the overall importance of the individual nodes. During fMRI scanning, participants imagined separate episodes, each involving one of the people and places, thereby reinstating their individual neural representations. Using representational-similarity analysis, we demonstrate that parts of the mPFC code for the individual nodes. Critically, we then show that the strength of the edges connecting these nodes is best explained by their importance. We thus provide evidence that the mPFC encodes affective schematic representations that may account for the involvement of this region in many disparate functions.

# Memory and Plasticity

## T11

### **Acute physical exercise rescues entorhinal spatial coding in young APOE carriers - preliminary results**

Blanca Marin Bosch<sup>\*1</sup>, Kinga Igloi<sup>\*1, 2</sup>, Misun Kim<sup>3</sup>, Noémie Kuenzi<sup>1</sup>, Aurélien Bringard<sup>1</sup>, Tobias Navarro-Schroeder<sup>4</sup>, Christian Doeller<sup>\*\*3, 4</sup>, Sophie Schwartz<sup>\*\*1, 2</sup>

<sup>1</sup>Department of Fundamental Neurosciences, University of Geneva, <sup>2</sup>Swiss Center for Affective Sciences, University of Geneva, <sup>3</sup>Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, <sup>4</sup>Kavli Institute for Systems Neuroscience, Centre for Neural Computation, The Egil and Pauline Braathen and Fred Kavli Centre for Cortical Microcircuits, Norwegian University of Science and Technology, Trondheim, Norway.

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The e4 isoform of the APOE gene, carried by about 20% of the population, is the most important genetic risk factor for late onset Alzheimer's disease. Alzheimer's disease is characterized by progressive memory and neural plasticity loss, starting in the entorhinal cortex and the hippocampus. A recent study showed that healthy young people carrying the e4 risk allele display early deficits in grid-cell-like representations in the right entorhinal cortex in a spatial memory task (Kunz et al 2015). Converging results from rodent and human literature also suggested that acute physical exercise may improve memory functions by increasing plasticity in the hippocampus and surrounding areas. Based on these findings, here we hypothesized that acute physical exercise would compensate early plasticity deficits displayed by e4-carriers. To test this hypothesis, we recruited control participants (homozygous e3) and at-risk participants (e3/e4). All participants came twice to the lab: once they rested for 30 minutes and once they cycled for 30 minutes, before they performed a spatial navigation task in the MRI. Our preliminary results replicate previous findings from Kunz et al (2015) showing a significant difference between right entorhinal activity of the control and of risk group after rest. Then, when looking at the effects of exercise, we report an interaction between genotype and rest vs. exercise sessions, whereby grid-cell-like representations in the right EC were improved after exercise, selectively in the risk group, suggesting that acute physical exercise may compensate for early neural plasticity deficits in the risk group.



# Memory and Plasticity

**T12** ★

## **Homo Cyberneticus: Neurocognitive considerations for the embodiment of artificial limbs.**

Tamar Makin<sup>1</sup>

<sup>1</sup>Institute of Cognitive Neuroscience, UCL, London, UK

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(When) should we all get artificial limbs? Technology is progressing at a remarkable pace, providing us with wearable robotic technologies to substitute, and even supplement, our own limbs, freeing humans from the biological constraints of their own bodies. But can the human brain embody these exciting technologies as new body parts? I will describe very recent neuroimaging and behavioural studies we've been conducting in amputees who use prosthetic limbs to substitute their missing hand function. We find that although brain resources originally devoted to body representation can be utilised to represent an artificial limb, the representational features of a prosthesis do not mimic that of a biological hand. These studies provide a first glimpse into neurocognitive opportunities and limitations towards artificial limb embodiment. I will then present ongoing studies examining what happens to people's (intact) biological body representation after they are provided with robotic augmentation – a Third Thumb. If you want to know what happens... please attend the talk! The bottom line is that our intuitions as scientists (mainly inspired by sci fi culture) tend to fail us when hypothesising on how the brain interfaces with wearable technology, so there are many pertinent open questions that await further research.

*Wednesday*

## **Ultra-High Field fMRI**

**T13** ★

### **New Maps of Activation, Connectivity, and Hierarchy using Ultra-high resolution fMRI and endogenous blood volume contrast**

Peter Bandettini<sup>1</sup>

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Functional MRI methodology continues to advance as methods for extracting functional information at high resolution and from time series fluctuations develops. In recent years, a primary focus of our lab has been on Sub-millimeter Resolution and specifically layer fMRI. To achieve our results, we have been scanning at 7T using non-invasive blood volume contrast, known as VASO. We have been able to resolve layer specific modulation with a finger movement task, individual motor and sensory digit representation, and layer specific differential activation in dorsal lateral prefrontal cortex between working memory/manipulation and subject response. We have also been mapping layer specific connectivity using resting state fMRI, revealing a hierarchal structure in the motor and visual systems. I will also show preliminary work showing layer specific activity in response to a naturalistic movie viewing task. As we use VASO we have been, up until now, up against a limit of spatial coverage and temporal resolution. At the end of this talk I will show recent VASO pulse sequence modifications, carried out by Dr. Laurentius Huber, that allow whole brain as well as high temporal resolution VASO, opening up the ability to perform whole brain layer specific connectivity analysis.

# Ultra-High Field fMRI

## T14

### **EEG and fMRI connectomes are reliably related: a concurrent EEG-fMRI study from 1.5T to 7T**

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Both the Electroencephalogram (EEG) and functional Magnetic Resonance Imaging (fMRI) are non-invasive methods to capture human brain activity. Both modalities can map the functional connectivity structure at the whole-brain scale and a moderate but significant correlation between connectivity of both modalities exists. The reliability of those measures in a concurrent EEG-fMRI setup remains unknown, notably with respect to changes as a function of MR-scanners with different field strengths and different number of EEG electrodes. We investigated the reliability of bimodal EEG-fMRI functional connectome acquired from resting-state concurrent recordings in a total of 72 subjects from four different imaging centers. Data was acquired from a 1.5T, 3T and a 7T scanner while using 64 or 256 EEG-electrodes. We demonstrate that the whole-brain connectivity correlation between EEG and fMRI of  $r \approx 0.3$  can be reliably retrieved from 1.5T to 7T. Increasing EEG electrodes from 64 to 256 did not result in an improvement of the correlation between connectivity measures. This study confirms, using different recording setups, that concurrent EEG-fMRI can be used to get a consistent estimate of multimodal functional connectomes. This opens new avenues for estimating the dynamics of brain function and better understand interactions between EEG and fMRI measures. This may be used as a clinical marker of pathological brain function.

# Ultra-High Field fMRI

## T15

### **Non-invasive brain stimulation transiently reinstates low gamma sampling and boost phonological processing in adults with dyslexia**

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Recent findings have linked developmental dyslexia to altered auditory cortex sampling within the low gamma range. Building upon the evidence that adults with dyslexia have reduced responses in left auditory cortex around 30 Hz, we used transcranial alternating current stimulation (tACS) to reinstate functional sampling in the left auditory region and assess whether it can boost phonological abilities. With this approach, we aim at corroborating the causal role of gamma oscillations in phonemic representation, their involvement in dyslexia, together with proposing the use of an experimental approach to directly restore the dysfunctional neural circuits. For each participant, we evaluated phonological abilities before a 20 minutes 30Hz tACS session, immediately after and 1h after, as well as for 60Hz and sham tACS. We used auditory steady state EEG responses to amplitude modulated sounds to entrain brain oscillations in a frequency specific manner. We found that phonemic processing and reading accuracy improved immediately after 30Hz tACS, commensurately to the severity of dyslexia. This effect was not present after 60Hz-tACS and after sham stimulation. No significant 30Hz effect was observed in a control group. Performance increase immediately after 30Hz tACS was accompanied by a selective increase in auditory cortex response to acoustic stimuli modulated at 30Hz. Power analysis in the source space showed, in dyslexics, an increased activation in the left primary auditory region and superior temporal gyrus. These results provide a strong evidence for the causal role of low gamma oscillations in phonological processing, and an involvement of oscillatory mechanisms in dyslexia.

# Ultra-High Field fMRI

**T16** ★

## Visual Predictions in different layers of visual cortex

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Normal brain function involves the interaction of internal processes with incoming sensory stimuli. We have created a series of brain imaging experiments that sample internal models and feedback mechanisms in early visual cortex. Primary visual cortex (V1) is the entry-stage for cortical processing of visual information. We can show that there are two information counter-streams concerned with: (1) retinotopic visual input and (2) top-down predictions of internal models generated by the brain. Our results speak to the conceptual framework of predictive coding. Internal models amplify and disamplify incoming information. The brain is a prediction-machinery. Healthy brain function will strike a balance between precision of prediction and prediction update based on prediction error. Our results incorporate state of the art, layer-specific ultra-high field fMRI and other imaging techniques. We argue that fMRI with its capability of measuring dendritic energy consumption is sensitive to record activity in different parts of layer spanning neurons which enriches our computational understanding of counter stream brain mechanisms.

*Thursday*

## **Brain Imaging across the Lifespan**

**T17** ★

### **Human Cognitive Aging: Maintenance Versus Dedifferentiation**

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Human cognitive aging differs between and is malleable within individuals. In the absence of a strong genetic program, it is open to a host of hazards, such as vascular and metabolic risk, but also open to protective and enhancing factors, such as experience-dependent cognitive plasticity. Longitudinal studies suggest that leading an intellectually challenging, physically active, and socially engaged life might mitigate losses and consolidate gains, but results need to be interpreted with caution, as individuals are not randomly assigned to lifestyles. In my presentation, I will report on (i) the role education in adult cognitive development; (ii) the degree to which individual differences in cognitive decline generalize across abilities; and (iii) the search for domain-general causes of cognitive aging that reduce the distinctiveness of representations and processing pathways.



# Brain Imaging across the Lifespan

**T18**

## **The impact of ischemic stroke on connectivity gradients**

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Recent studies have demonstrated a newly presented analytic approach to resting-state connectivity data that captures brain organization as a low-dimensional space that reflects its macroscale hierarchy. The dimensions of this space, described as connectivity gradients, represent the similarity of areas' connections along a continuous space. Here, we studied how pathological perturbations with known effects on functional connectivity affect these connectivity gradients in order to provide support for their biological relevance. Stroke, even if localized is known to cause widespread functional connectivity alterations in structurally intact areas, affecting a network of interconnected regions. We therefore used acute stroke as a model and applied the connectivity gradient framework to depict how functional reorganization occurs throughout the brain, unrestricted by traditional definitions of functional network boundaries. Longitudinal resting-state functional magnetic resonance imaging data was acquired from 54 acute stroke patients during the first week after symptoms onset. We defined a three-dimensional connectivity space template based on functional connectivity data from 31 healthy controls. By projecting lesion locations into this space, we demonstrate that ischemic strokes result in dimension-specific alterations in functional connectivity. Specifically, changes in functional connectivity were captured along connectivity Gradients 1 and 3. The degree of functional connectivity change was associated with the distance from the lesion along these connectivity gradients (a measure of functional similarity) regardless of the anatomical distance from the lesion. Together, these results provide support for the biological validity of connectivity gradients and suggest a novel framework to characterize connectivity alterations after stroke.

# Brain Imaging across the Lifespan

## T19

### **Moment-to-moment variability in visual cortex robustly predicts anxiety disorder patient responses to psychological treatment**

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There is considerable interindividual variability in psychiatric patient responses to treatment. Tools in translational neuroscience may be helpful to predict patient's future outcome in treatment (e.g., using functional magnetic resonance imaging (fMRI) to estimate socio-emotional neural responses). Blood-oxygen level-dependent (BOLD) variability (e.g., voxel-wise SDBOLD) has emerged as an alternative and promising approach for understanding human cognition, but has rarely been considered as a marker of clinical outcome. Here, 46 social anxiety disorder patients were scanned (3T BOLD-fMRI) twice (9 weeks apart) prior to treatment. In each scanning session, patients repeatedly and passively viewed facial expressions for 160 seconds. After baseline scanning, patients underwent cognitive behavioral therapy (CBT) for 9 weeks. Multivariate partial least squares (PLS) models were used to link SDBOLD to treatment outcome (anxiety pre-post change scores), and latent level brain scores were implemented in several subsequent linear regression models. Treatment outcome varied across patients, but yielded a large effect on anxiety symptom reduction (Cohen's  $d = 1.5$ ) on a group-level. Behavioral PLS models strongly revealed lower visual cortex SDBOLD in patients with more favorable treatment outcomes (first session:  $\beta = .77$ , Adj-R<sup>2</sup> = .58; and second session  $\beta = .78$ , Adj-R<sup>2</sup> = .60). K-fold cross-validation further supported our results, demonstrating a 60-70% reduction in model out-of-sample prediction error when SDBOLD was included as a predictor. Our findings provide first evidence that moment-to-moment variability in neural responses shows translational potential by accurately predicting psychiatric patients' future treatment outcomes. If replicated, brain signal variability-based prediction may provide an efficient and viable future tool in clinical psychiatry.

# Brain Imaging across the Lifespan

## T20

### **Structural neuroplastic responses preserve functional connectivity and neurobehavioural outcomes through strengthening of intra-hemispheric pathways in children born without a corpus callosum**

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The corpus callosum is the largest white matter pathway in the brain connecting the two hemispheres. Developmental absence (agenesis) of the corpus callosum is a model disease for exploring disrupted connectivity and in turn understanding plasticity of the human brain, with atypically developing structure and function resulting in a highly heterogeneous clinical and cognitive profile. A proposed candidate for neuroplastic response in the context of this brain malformation is strengthening of intra-hemispheric pathways. To test this hypothesis, we assessed structural and functional connectivity in a uniquely large cohort of children with AgCC (n=20) compared with typically developing controls (TDC, n=29), and then examined associations with neurobehavioural outcomes using a multivariate data-driven approach (partial least squares correlation). For structural connectivity, children with AgCC showed a significant increase in intra-hemispheric connectivity in addition to a significant decrease in inter-hemispheric connectivity compared with TDC, in line with the hypothesis of structural strengthening of intra-hemispheric pathways in children born without corpus callosum. In contrast, for functional connectivity, children with AgCC and TDC showed a similar pattern of intra-hemispheric and inter-hemispheric connectivity. In AgCC, structural strengthening of the intra-hemispheric pathway was uniquely associated with verbal learning and memory, attention and executive measures. This novel evidence improves our current understanding of neuroplastic responses in children with AgCC and their role in the inter-individual heterogeneity in neurobehavioural outcomes observed in this population.

# Special 15 Years Celebration Lecture

**T21** ★

## **Why study Brain Adaptation to change under real life extreme situation?**

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Since 2014, the Human Adaptation Institute has been working on methodologies to study how the human brain and associated cognitive abilities adapt to situations of extreme climate change or other changes, in real-life situation. Complex protocols using current means of cognitive neuroscience are indispensable in an increasingly changing global context, for which the simulated methods – so useful elsewhere – cannot provide satisfactory answers. Review of the current methodologies implemented in real life situations and initial results.

# **POSTER ABSTRACTS**

Ordered according to these categories:

Clinical Neuroscience

Emotion & Motivation

Language & Music

Learning & Memory

Methods

Perception

### **Neural processing and interpretation of physical social interaction in disruptive behavior disorders**

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**Introduction** In children and adolescents, a tendency to interpret hostile intention in others is postulated to play an important role in the development and maintenance of social adjustment problems such as disruptive behavior disorders (DBD). However, little is known about the underlying neural processing of ambiguous and hostile social interaction. We investigated the role of callous-unemotional (CU) traits and physical aggression among children and adolescents with DBD and healthy controls (CG) in the interpretation and neural processing of physical social interaction using fMRI.

**Methods** Thirty-seven youth with DBD (aged 9-17,  $M = 13.6$  (1.9), 17 female) and 37 age- and gender-matched healthy controls (CG; aged 10-18,  $M = 13.9$  (2.1), 17 female) viewed friendly, ambiguous and hostile line drawings of physical interaction while in the MRI scanner. After viewing, participants rated the friendliness vs. hostility of each interaction.

**Results** Results showed increased hostility ratings of friendly interaction in males and females with DBD compared to CG. Physical aggression corresponded to increased neural activation in hostile > ambiguous as well as hostile > friendly scenes in left insula, inferior frontal gyrus (IFG), temporal pole and superior temporal gyrus. In contrast, CU corresponded to increased activation in ambiguous > hostile as well as friendly > hostile scenes in dorsal anterior cingulate cortex, left insula/IFG, temporal pole, and superior temporal gyrus.

**Conclusions** Physical aggression and CU traits show inverse associations and a suppressor effect within socio-emotional processing network nodes while processing physical social interaction among others. Hostile scenes might show higher relevance than ambiguous scenes for physically aggressive individuals due to the greater immediate physical threat they depict. The neural response may thus reflect an attentional bias to salient hostile cues. In contrast, processing of friendly and ambiguous social signals may be of higher relevance for behavioral goals in individuals with high CU traits, such as the effective manipulation of others, for which an understanding of others' motives in complex social interactions is necessary.

### **Presence hallucination in Parkinson's disease: sensorimotor conflict, functional disconnection and cognitive decline**

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Hallucinations in Parkinson's disease (PD) are frequent, progressive and constitute a significant risk factor for adverse clinical outcomes, such as dementia. Therefore, early detection of hallucinations is crucial for an appropriate adjustment of treatments and limiting their progression in severity. Despite the high prevalence and the importance of early detection, hallucinations are underdiagnosed and very little is known about their neural correlates. Presence hallucination (PH), the sensation that somebody is nearby when no one is present, is among the first hallucinations occurring, among the more frequent, and might predict the onset of more severe hallucinations and psychosis. Here, we developed a robotic system that generates specific sensorimotor conflicts that allowed us to induce the PH in patients with PD (with the clinical PH: PD-PH and without PD-nPH) and healthy controls (HC). Interestingly, PD-PH reported that the PH robotically-induced mimicked the sensations of the clinical PH. Our behavioral data show that the intensity of the robot-induced PH is positively modulated by the degree of the sensorimotor conflict and that the qualitative and quantitative experience of the robot-induced PH differs among the three sub-groups. Finally, using fMRI, we identified the functional processes that are associated with PH in PD, within the neural network previously associated with the robotic-induced sensorimotor stimulation (in healthy participants). In addition, the degree of functional disconnection was associated with cognitive decline, selectively for PD-PH. These results represent the first delineation of the mechanism of hallucinations and provide new insights and technology to quantify and qualify hallucinations in PD.

### **Functional graph measures in progressive multiple sclerosis patients**

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**Background:** Functional connectivity (FC) in patients with progressive multiple sclerosis (MS) has received limited attention so far, with previous discordant results. Network-based methodologies have been recently applied to MS, but on samples including mainly patients with relapsing-remitting MS. We investigated alterations in FC, using a network-based approach, in primary and secondary progressive MS patients (PP-MS and SP-MS, respectively).

**Materials and Methods:** Nineteen patients with PP-MS, 14 patients with SP-MS and 25 healthy subjects (HS) were included. Functional ROIs were generated using the Schaefer atlas and connectivity matrices were obtained. Network properties (NP) were derived for each subject and differences of NP among the three groups and their relationship with measures of cognitive status were assessed.

**Results:** PP-MS patients, compared to HS, showed higher values in the NP at the level of insular and prefrontal regions, but lower NP values at the level of the bilateral temporal areas and precuneus while SP-MS showed lower values at the level of parietal regions and insula. NP values at the level of the insular regions and the precuneus positively correlated with symbol digit modalities test in SP-MS and PP-MS patients, respectively.

**Conclusion:** Although PP-MS and SP-MS patients are often grouped together in studies on FC, they present with a different pattern in terms of altered functional network properties which also correlates to cognitive measures. Further efforts in distinguishing the functional alterations in two clinical phenotypes could shed light in the understanding of the underlying pathophysiological process.



### Differences in resting state networks in epileptic patients and controls

Margherita Carboni<sup>1, 2</sup>, Pia De Stefano<sup>1</sup>, Bernd Vorderwulbecke<sup>1</sup>, Sebastien Tourbier<sup>3</sup>, Emeline Muller<sup>3</sup>, Maria Rubega<sup>2, 4</sup>, Shahan Momjian<sup>5</sup>, Karl Schaller<sup>5</sup>, Patric Hagmann<sup>3</sup>, Margitta Seeck<sup>1</sup>, Christoph Michel<sup>2</sup>, Pieter Van Mierlo<sup>1, 6</sup>, Serge Vulliemoz<sup>1</sup>

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**Objective:** Some patients with epilepsy don't show epileptic activity between seizures on EEG, therefore, the diagnosis is challenging. We investigated whether patients had altered features in large-scale functional networks using resting-state high-density-EEG without pathological activity.

**Methods:** We analysed 49 adult patients with focal epilepsy and 19 healthy controls with high-density-EEG and structural-MRI. We estimated cortical activity during resting-state using electric-source-analysis in 82 cortical regions. We applied directed connectivity analysis (Partial Directed Coherence) on sources and performed graph analysis: we computed the efficiency at whole brain and within each resting-state-network. We compared these two measures between patients and controls.

**Results:** We found higher global efficiency in patients both with temporal and extra-temporal lobe epilepsy as compared to controls ( $p < 0.05$ ). We found significantly ( $p < 0.05$ ) higher efficiency in somato-motor-network, ventral-attention-network and default-mode-network in (a) all patients, (b) temporal lobe, (c) left temporal lobe, (d) temporal lobe with hippocampal sclerosis as compared to controls. In patients with right temporal epilepsy, only somato-motor-network and ventral-attention-network had significantly higher efficiency ( $p < 0.05$ , corrected) as compared to controls.

**Conclusions:** Patients with focal epilepsy show functional connectivity alterations at global level and in some resting state networks. Higher efficiency (also found during epileptic spikes in a previous study) may be related to mechanisms of propagation of epileptic activity. This could help to diagnose epilepsy in the absence of any interictal epileptic activity on scalp EEG. Alterations in the canonical resting state networks may relate to alterations in cognitive functions in the absence of scalp EEG abnormalities.

### **Deficits in cognitive and affective theory of mind relate to common lesion patterns in temporo-parietal junction, but not insular and prefrontal cortex**

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Understanding emotions in others typically engages brain regions in temporal and prefrontal cortices, a network often associated with more general cognitive Theory-of Mind (ToM) functions allowing us to infer people's beliefs or intentions. However, patients with damage in these regions (especially the prefrontal cortex) reveal dissociations between the ability to understand others' emotions and ToM. Here, we directly investigated whether deficits in understanding people's emotions show similar or differential lesion patterns as opposed to deficits in understanding non-emotional cognitive states. By combining information from 40 unilateral stroke damaged patients, with normative connectome data from 93 neurotypical individuals, we estimated lesion-induced dysfunctions across the whole brain, and modeled them in relation to patients' behavior. We found a striking dissociation between the temporo-parietal junction, whose dysfunctions led to common impairments in understanding emotions and beliefs, and the insular and prefrontal cortex, that were selectively implicated in deficits for affective processing and ToM respectively. Our data provide novel causal evidence of segregation between brain networks subserving social inferential abilities, supporting multiple-pathway accounts according to which others' emotions can be processed either through ToM processes in the temporal cortex, or more selective mechanisms in the insula.

**Effects of antipsychotic treatment on EEG resting-state microstates in patients with psychotic disorders**

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Resting-state EEG is a powerful tool to study global brain network connectivity. One measure, EEG microstates, is increasingly implicated in psychotic disorders. While previous studies included both antipsychotic medicated and medication naïve patients, no study has directly investigated the effect of antipsychotic medication on EEG microstates yet. Therefore, this study used a longitudinal design in which patients with psychotic disorders were assessed at two timepoints: before and after 8-10 weeks of antipsychotic medication. In the present analysis, we included 14 participants. Resting-state (10 minutes, eyes-closed) EEG recordings were used to compute microstates, which were clustered into four classes (A-D) according to their topography and established norms. Temporal parameters (coverage, duration, and occurrence) were calculated and compared between pre- and post-medication using 2 (day) x 4 (microstate class) repeated measures ANOVAs. Preliminary analyses show no significant differences between pre- and post-medication. The negative results might be attributed to low statistical power (small sample size); recruitment for the study is still ongoing.

### **Control over brain networks associated with robotically-mediated hallucinations through dynamic functional connectivity based real-time fMRI neurofeedback**

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The presence hallucination (PH) is a convincing sensation of having someone else close by when no one is actually there [1]. Having been reported in both neurological populations [1], and healthy individuals undergoing adverse conditions [2], two studies have experimentally induced this sensation in the latter group through robotically mediated sensorimotor conflicts [3, 4]. The latest study, with fMRI, highlighted key regions associated with this robotically-induced PH, namely the posterior middle temporal gyrus, and the anterior insula [4]. Finally, a follow-up study using Co-Activation Pattern analysis [5], identified a fronto-parietal network which occurrence is significantly increase during the PH-inducing condition [6]. In the currently ongoing real-time fMRI neurofeedback study, healthy participants are being trained to achieve volitional control of the above described PH-network [6]. During a 5 days experimental paradigm, participants complete a first day of robotically mediated PH-induction in the MR scanner, followed by three days of connectivity-based neurofeedback paired with robotic manipulation, and a final day of post-training PH-induction in the MR scanner. Our main goal is to assess if healthy individuals can increase the occurrence of the network linked to the PH through neurofeedback, and if so, quantify the impact that this modulation will have in both the intensity of the experienced PH, and PH-network occurrence, when comparing pre and post training behavioural inductions of the PH.

### **Real-time fMRI neurofeedback as treatment for intercritical mood symptoms in bipolar disorder: a randomized controlled trial**

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Bipolar disorder (BD) is a severe mood disorder characterized by episodes of mania (euphoria) and depression. Between acute episodes, i.e., during euthymic periods, “residual” emotional and depressive symptoms may persist. While residual symptoms are less intense, they are nevertheless disabling and contribute to chronic functional impairment and risk of relapse. The efficacy of pharmacological treatments in managing acute episodes in BD has already been demonstrated; however, there are very few treatment options for residual symptoms. Real-time functional magnetic resonance imaging (fMRI) neurofeedback (NFB) has already been shown to be effective in self-regulating brain function, behavior and decreasing depressive symptoms in people with major depressive disorder (MDD). This multi-centric study aims at assessing the efficacy of 3-weeks neurofeedback training with real-time fMRI on the treatment of residual mood symptoms in patients with BD. We will specifically target depressive symptoms by training the patients to decrease the amygdala’s hemodynamic response to emotional stimuli. Stabilized patients with BD will be randomly assigned to the experimental group (receiving feedback from amygdala hemodynamic activity) or control group (receiving the signal from a control brain area not involved in emotion processing). NFB training sessions will include one baseline run, three training runs and a transfer run. We expect a significant reduction in Montgomery-Asberg Depression Rating Scale (MADRS) Total Score after 3 weeks of neurofeedback training in patients receiving the feedback from the amygdala (active group) in comparison to those receiving the feedback from a control brain region (sham group).

## **Magnetic resonance imaging to understand idiopathic Normal Pressure Hydrocephalus in the elderly**

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Idiopathic normal pressure hydrocephalus (iNPH) is a prevalent neurological disorder characterized by impaired locomotion, cognition and urinary control with ventriculomegaly. Symptoms can be relieved with cerebrospinal-fluid (CSF) drainage, which makes iNPH the leading cause of reversible dementia. iNPH is frequently associated with behavioral-emotional disorders, including anxiety/fear of falling (FOF), that further impair life quality and predict poor clinical outcomes. INPH is still a poorly understood disorder with difficult diagnosis because of unspecific symptoms and prevalence of comorbidities (e.g., Alzheimer's disease). Therefore, there is an urgent need for noninvasive quantitative markers reflecting iNPH symptoms and behavioral-emotional dimensions, able to track brain recovery mechanisms after CSF drainage. To this end, we propose to quantify functional and structural changes of brain networks in relation to iNPH symptoms, before and after a lumbar puncture for CSF drainage. Here, (i) we detail the protocol of our study, which includes cognitive, gait and neuroimaging (MRI) assessment; (ii) reinforce the conceptualization of iNPH as to brain network mechanisms, by performing a functional imaging meta-analysis of iNPH symptoms in healthy populations. This analysis highlights the salience network with the insula, attentional networks and a rostro-caudal axis in the medial-prefrontal cortex as key circuits of iNPH. In addition, we build up on a locomotion meta-analysis to carry out a preliminary, hypothesis-driven resting-state fMRI investigation of FOF in (control) older adults. A partial least square analysis of seed-based functional connectivity suggests that FOF is associated with dysconnectivity between dorsolateral-prefrontal cortex and posterior insula, two regions involved in higher-order locomotor control.

## **CYP2C19 expression, hippocampal volume and influence on global functioning**

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Polymorphic CYP2C19 is responsible for metabolizing many psychoactive compounds. CYP2C19 poor metabolizer (PMs) status has previously been found to be associated with lower depressive symptoms and with bigger bilateral hippocampal volumes as compared to other metabolizers (OMs). We aimed to build on these findings and to identify additional behavioral effects associated with CYP2C19 activity in a population-based cohort from Lausanne, Switzerland (PsyCoLaus, N= 2510; BrainLaus, N=330). General linear models were used to test the associations between psychological test results (Global Assessment of Functioning–lifetime or GAF-L, and State-Trait Anxiety Inventory–trait or STAI-t), and genotypes, controlling for age and sex. In addition, we analyzed using Statistical Parametric Mapping multi-contrast anatomical MRI data sensitive to myelin, iron and tissue water to derive estimates of hippocampus volume and brain tissue properties controlling for age, sex and intracranial volume (n=330). PMs (n=74) had better scores in GAF-L scores than OMs (n=2436; p=0.035) while no significant result was observed for STAI-t scores (p=0.4). No significant differences were found between the two groups for global hippocampal volume or multi-parameter maps. A trend for an increase in the volume of the left subiculum was found in PMs compared to OMs (mean diff=0.02cm<sup>3</sup>, pcorrected=0.07). In conclusion, in agreement with a previous study, we showed that CYP2C19 PMs have a better global functioning compared to OMs. Although we did not find a significant relationship between hippocampal volume and genotypes, a borderline association was found between CYP2C19 PMs status and an increase in the left subiculum volume.

### **Train the brain with music (TBM): Brain plasticity and cognitive benefits induced by musical training in elderly people in Germany and Switzerland, an RCT comparing musical instrumental practice to sensitization to music**

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Cognitive decline represents a major impediment to healthy aging. A challenge in the field of aging is to develop training regimens that stimulate neuroprotection mechanisms and delay or reverse symptoms of cognitive and cerebral decline. To be successful, these regimens should be easily integrated in daily life and intrinsically motivating. Recent studies suggest musical practice represents a promising approach, but experimental evidence remains sparse. This study combines for the first-time protocolled music practice in elderly with cutting-edge neuroimaging and behavioral testing, moreover, comparing two types of musical education. We apply a multi-site longitudinal randomized intervention study in altogether 150 retired healthy elderly in Geneva and Hannover, offering either piano (intervention group) or musical sensitization education (active control group). Over 12 months participants receive weekly training for one hour, and exercise at home for ~30 minutes daily. Measurements take place at 4 time points (0-6-12 months & post-training at 18 months) on large-scale cognitive and perceptual-motor abilities, wide-ranging functional and structural neuroimaging and blood sampling. We hypothesize demonstrating positive transfer effects for faculties traditionally described to decline with age, particularly in the piano group: executive functions, working memory, processing speed, abstract thinking and fine motor skills and in both groups for verbal memory, hearing in noise and subjective well-being. In association with these behavioral benefits we anticipate functional and structural brain plasticity in temporal (medial and lateral), prefrontal and parietal areas, and potential links with epigenetic expression. In this poster we will present the ongoing study protocol, which we submitted recently.



### **Effects of a music intervention on brain structure and executive functioning in healthy elderly after 6 months: a randomized controlled trial on piano practice versus music sensitization**

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Cognitive decline represents a main threat among the negative effects of aging, heavily impacting quality of life and autonomy of elderly. Recent data suggest that musical practice might prevent age-related cognitive decline, but experimental evidence remains sparse. This study combines for the first-time protocolled music practice in elderly with cutting-edge neuroimaging, moreover, comparing two types of musical education. Our two-site Hannover-Geneva longitudinal randomized intervention study in altogether 150 elderly offers either piano (intervention group) or music sensitization education (active control group). Over 12 months participants receive weekly training (60 minutes) and exercise at home for ~30 minutes daily. Measurements take place at 4 time points (0, 6, 12 months & post-training (18 months)) on cognitive and perceptual-motor abilities (comprehensive behavioral battery of 15 tests) as well as on brain structural and functional magnetic resonance imaging (MRI) (see C. James' abstract on the protocol). We will present here preliminary results of the intervention in Geneva subgroup (N=62) after 6 months of musical training, concerning behavioral and brain data comparing both groups. Firstly, we will present structural plasticity changes separately in both groups between baseline and 6 months, as well as group comparisons and relate those results to the amount of training (questionnaire documenting daily homework). Secondly, we expect to report positive transfer effects for executive functions, larger in the piano group than the control group, in particular for working memory. This behavioral change may relate to functional plasticity in fronto-parietal areas as measured by a functional MRI tonal working memory task.

## **Differences in EEG microstates of medicated and unmedicated first-episode psychotic patients and healthy controls**

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EEG resting-state microstates are quasi-stable topographies of scalp electric potential; four microstate classes (A-D) have been described in healthy individuals (HC) and are considered to reflect global network connectivity. There is accumulating evidence that drug-naïve patients with schizophrenia exhibit abnormalities in microstate classes, consistent with the disconnectivity hypothesis of schizophrenia with changes in microstates C and D found to be most prominent by a recent meta-analysis. However, there is scarce evidence regarding the effect of antipsychotic medication on microstates. We examined the difference between medicated (MFEP) and unmedicated (UFEP) first-episode psychotic patients compared to HC. We hypothesized that UFEP would exhibit microstate changes compared to both MFEP and HC. Resting-state, eyes-closed, 19-channel EEG was recorded in all study groups (MFEP = 17, UFEP=29, HC=25). Microstates were clustered into four microstate classes (A-D) according to their topography and sorted by the established norms by Koenig et al. (2002). The percentage of analysis time covered by each microstate was the variable of interest. A 3 (group) x 4 (microstate class) ANOVA was significant ( $F=4.82$ ,  $p<0.001$ ). Follow-up ANOVAs indicated significant group differences for microstate A ( $F=12.95$ ,  $p<0.001$ ; UFEP > MFEP = HC in pairwise comparisons) and B ( $F=4.19$ ,  $p=0.02$ ; UFEP < MFEP); a trend was noted for microstate D ( $F=2.49$ ,  $p=0.09$ ; UFEP < MFEP). Our results indicate that treatment with antipsychotics potentially reverses resting-state EEG microstate abnormalities that are characteristic of schizophrenia. MFEP did not differ from HC, which further supports this conclusion.

### **Abnormal development and dysconnectivity of the thalamus in patients with 22q11DS experiencing auditory hallucinations**

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Several studies in patients with schizophrenia have extensively demonstrated an abnormal thalamic volume and thalamocortical connectivity. In particular, hyperconnectivity with somatosensory areas has been related to the presence of auditory hallucinations (AH). The 22q11.2 deletion syndrome (22q11DS) is neurogenetic disorder conferring proneness to develop schizophrenia. We acquired 232 consecutive MRIs from 120 patients with 22q11DS approximately every 3 years (age-range: 10-35 years). The volume of thalamic subnuclei was obtained with FreeSurfer and was compared between those patients with or without symptoms of AH. Then, in a subgroup of 76 patients, we evaluated the functional connectivity between the thalamic nuclei affected in patients experiencing AH and cortical regions. Deletion carriers with AH had a smaller volume of the medial geniculate nucleus (MGN) with an aberrant developmental trajectory showing a steeper volume decrease from childhood. Moreover, we found an aberrant development of nuclei intercalated between prefrontal cortex and the hippocampus, as the anteroventral nucleus (AV). When analyzing the functional connectivity of the MGN and AV, we found hyperconnectivity with the auditory cortex and Wernicke's area related to AH. Overall, our findings point towards an aberrant development of the structure and function of the MGN in patients with 22q11DS experiencing AH. Interestingly, these results are in line with a study demonstrating disruption of thalamocortical projections to the auditory cortex in mice models of 22q11DS. The increased connectivity of the AV to the auditory cortex might be interpreted as a lack of maturation of thalamocortical connectivity in deletion carriers with AH.

### **The neural correlates of face-voice-integration in social anxiety disorder**

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**Introduction:** Social anxiety disorder (SAD) is centered on the fear of negative evaluation. It is frequent and characterized by a heightened sensitivity to social threat, both behaviorally and neuronally through altered cerebral activation patterns. Social anxiety (SA) is also associated with a generally increased sensitivity of specialized voice and face processing areas to these cues as threat carrier signals. It remains unclear, however, if also the cerebral integration of voices and faces is increased in SAD.

**Methods:** 18 individuals with SAD and 18 healthy individuals participated in a functional magnetic resonance imaging experiment evaluating the audiovisual integration of voices and faces. The intensity of integration effects (standard voxel-wise and psychophysiological interaction analyses) and the spatial distribution of individual integration maxima were evaluated.

**Results and Conclusions:** Increased hemodynamic audiovisual integration correlates in SAD were detected in the superior temporal sulcus (STS) accompanied by stronger integration-related increases in functional connectivity between STS and (peri-)striate visual cortex. Additionally, an anteriorization of individual integration maxima along the STS correlating with SA severity was observed. This demonstrates an alteration of the intensity but also the topography of the sensory integration of faces and voices as common threat carrier signals in SAD with increased functional connectivity patterns potentially representing a driving factor. Finally, the spatial distribution analysis with the anteriorized integration maximum in SAD may offer a novel perspective on the cerebral representation of social signal processing in SAD with relevance for other psychiatric disorders or personality traits as well as sensory integration research in general.

**The role of temporal, spatial and proprioceptive congruency in the multisensory representation of the upper limb**

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The subjective experience of the body as our own depends on the coherent integration of bodily signals. Body experience can be indeed manipulated by applying incongruent multimodal stimulation and is conceivable that pathological phenomena such as somatoparaphrenia or other milder forms of body disownership can be partially explained by an aberrant processing of bodily signals. Under normal conditions bodily stimuli have specific properties and physiological constraints that follow the rules of multisensory integration and natural physics, namely they are congruent in time, space and with the physical structure of the body. In this study we exploited different kinds of incongruency between visual and tactile stimuli in order to understand how different brain areas process temporal, spatial and proprioceptive constraints of bodily stimuli. We applied multivariate analysis techniques to abstract from the cortical spatial layout and study the fine-grained neural activity patterns. While some of these techniques have been already applied to investigate unimodal representation of body parts, we used this approach to find fingerprints of modality specific activity and multisensory interactions, especially in higher level association cortices, where many distinct functions of body and self-awareness spatially overlap.

### **Direct modulation of functional connectivity through neurofeedback in chronic stroke patients**

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Synchronization of neural activity as measured with functional connectivity (FC) is increasingly used to study the neural basis of brain disease and develop new treatment targets. However, we lack solid evidence for a causal role of FC in disease and therapy. Here, we manipulated FC of the primary motor cortex in human stroke patients through neurofeedback technology, and tested whether this had an effect on motor performance. Ten patients with chronic stroke voluntarily enhanced the global FC of their ipsilesional hand motor area (as measured with the graph theoretical measure weighted node degree) during eight neurofeedback sessions over one month. In a control condition, they trained the FC of their contralesional dorsolateral prefrontal cortex in a crossover design. FC was reconstructed in real-time from high-density EEG recordings as the imaginary coherence in the alpha frequency band, and visually presented to the patients using a cursor. Upper extremity motor performance was assessed before and after the month of training. Patients selectively increased the node degree in each target area during the respective neurofeedback sessions. During the month of motor coherence training, a significant increase in motor performance was observed, which was significantly greater than during training of the control area. The improvement in motor performance correlated significantly with the increase in FC of the targeted motor area during neurofeedback. Hence, a direct modulation of FC was specifically associated with proportional behavioral improvements providing evidence that FC has a causal role in neurological function and can be effectively targeted with therapy.

## **Emotion regulation traits predict cortico-limbic recovery to psychosocial stress**

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Emotional recovery from stress is an essential aspect of cognitive-affective resilience, adaptation and self-regulation. The Montreal Imaging Stress Task (MIST) is a validated tool to induce psychosocial stress within a functional magnetic resonance imaging (fMRI) environment, by asking the participant to perform mental calculations compared with the rest of the group. Here, we wished to investigate how the brain recovers from psychosocial stress, while accounting for anxiety and emotion regulation traits. Forty-seven healthy participants, 17-39 years, performed an adapted version of the MIST. After a series of calculations in a limited timeframe, they received positive, negative and neutral performance feedback along with their ranking. An 85-second rest period preceded each feedback. We collected trait anxiety, rumination and emotion regulation self-report scores. Rest subsequent to negative feedback yielded neural activations within the dorsomedial prefrontal cortex (dMPFC) and left amygdala, however this effect did not survive when controlling for anxiety, rumination and emotion regulation traits. Notably, we observed a significant positive correlation between neural activations during rest (positive > negative) and trait anxiety, brooding rumination, and maladaptive cognitive emotion regulation, but we also found specific regions associated with each trait. Reflecting on recent performance elicits neural activity that is likely mediated conjointly, but also differentially, by trait anxiety, ruminative tendencies, and emotion regulation strategies. Identifying these shared and distinct stress-induced activation patterns in cortico-limbic neural networks opens the possibility to determine if these dynamics may serve as risk factors for social-emotional dysregulation, often witnessed in psychopathologies like bipolar and borderline personality disorders.

## **Targeting neural interactions with optimal transcranial direct-current stimulation**

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Stroke patients can suffer from upper extremity disability. In patients with mild to moderate impairment, recent studies associated the increase of neural interactions of motor areas with an improvement of their clinical motor outcome. Transcranial direct-current stimulation (tDCS) is a non-invasive brain stimulation allowing the modulation of cortical excitability. We hypothesize that tDCS application with the right setup, can increase neural interactions of perilesional cortical areas leading to an improvement of motor recovery. The aim of this ongoing study is to evaluate the impact of four different tDCS montages (conventional anodal, bi-hemispheric, high-definition anodal, sham) on motor recovery. So far, thirteen patients completed the protocol which includes six sessions of tDCS stimulation during active motor therapy over two weeks. Upper limb motor function, quantified with the Fugl-Meyer assessment of the upper extremity, showed a trend of better improvement after the tDCS treatment in patients undergoing the bi-hemispheric tDCS stimulation than in the other study arms. This trend was enhanced at 3-month post-stroke follow-up. To better understand the neurophysiology underlying this difference, we assessed the motor evoked potentials (MEP) of the patients through transcranial magnetic stimulation. On the affected side, the MEPs had greater peak-to-peak amplitudes post-treatment than pre-treatment. Thus, these intermediary results suggest that bi-hemispheric tDCS facilitates motor recovery by inducing a robust increase in ipsilesional corticospinal excitability. Electro-encephalography calculations are on-going to assess the effect on intracortical interactions.



### **Efficient cognitive control during Transcutaneous Vagus Nerve Stimulation – preliminary evidence**

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We have previously shown vagus nerve stimulation (VNS) to improve working memory performance in patients with refractory epilepsy (Sun et al 2017). The current research focuses on transcutaneously applied non-invasive vagus nerve stimulation, tVNS, and whether tVNS has potential for enhancing cognitive functions. The goal of the study was to investigate whether tVNS had any effect on cognitive control functions. Healthy young subjects (n=25 age=25.2 ± 4.7 years) performed a Go-NoGo task, Executive Reaction time -test (RT-test), while their EEG was recorded. Active stimulation at the left tragus and sham stimulation at the left ear lobe were alternately delivered to subjects blind to stimulator status throughout the task. N2 and P3 ERP peak and N2P3 peak-to-peak amplitudes were measured as markers of cognitive control resources allocated to carry out the task. tVNS had no effect on any cognitive performance measures. Subjects committed very few errors in all conditions. tVNS resulted in a significant reduction in N2 peak amplitude (p<0.05) when compared to sham stimulation in “NoGo” condition. There were no effects on studied ERP peaks during Go condition. In Summary, no improvements nor decrements were found in cognitive performance along with diminished NoGo N2 potential. We conclude that fewer cognitive control resources were required to successfully withhold a prepotent response. Though caution is warranted in the interpretation of these preliminary results, tVNS may lead to a more efficient neural processing with less resources required for a successful cognitive control. Future studies are however required to confirm these results.

## **Influence of structure-function age-related changes on behavior using multimodal MR: A longitudinal study**

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Aging is associated with intra-individual structural and functional alterations, and unique connectivity patterns. Our longitudinal, within-subject, multimodal approach aims to combine brain data from structural magnetic resonance imaging (MRI), diffusion-weighted MRI (DW-MRI), and functional MRI (fMRI) with behavioral evaluation, to better understand how changes in functional (FC) and structural connectivity (SC) correlate with change in behavior in a sample of older adults. The participants underwent both MRI and a battery of neuropsychological tests covering multiple cognitive measures including simple reaction times, complex processing speed and inhibition at 2.5 years interval. Change in cognitive functioning was explored both in terms of amplitude and of heterogeneity. Within-individual ANOVAs (tasks and time as within factors) allowed assessing individual change of amplitude and heterogeneity independently of the sample characteristics. FC and SC were calculated using the Glasser atlas with custom pipelines in Matlab and mrtrix3, respectively. Preliminary results on a subsample (N=12) indicate that SC change in some connections (9, mostly temporo-parietal) is negatively correlated with mean amplitude of change for all tasks considered ( $p < 0.0005$ ), suggesting preservation of SC is associated with lesser change (more stability in behavior) across these tasks. Our within-subject approach minimizes inter-individual variability typical of cross-sectional designs and may help disentangling to what degree brain FC-SC connectivity ultimately drives aging-related changes in cognition, as well as assessing the behavioral relevance of FC-SC connectivity metrics. The use of Partial Least Squares Correlation will be explored in the near future as a framework for multivariate analysis.

### **Can we connect Freudian ideas to neuroscience? A fMRI-study on the default mode network and ego-functions**

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There is a less well-studied approach to personality, which is derived from Sigmund Freud's tripartite model of the ego, the id, and the super-ego: ego-functions. Here, personality is assessed through a person's structural integration; meaning how well they are able to regulate their self. With the advances in functional neuroscience, it has become possible to search for neural correlates of Freud's model. To this end, this study uses resting-state functional connectivity (RSFC) to investigate cortical midline structures (CMS) and the default mode network (DMN), both involved in self-referentiality, with respect to ego-functions.

A total of 90 healthy participants completed a resting-state session. Following functional MRI data acquisition, ego-functions, next to other personality measures, were assessed using the Operationalised Psychodynamic Diagnosis System Self-Questionnaire (OPD-SQ). Seed-based functional connectivity using the posterior cingulate cortex (PCC) within the DMN and additional seed regions from the CMS were used to analyze possible neural correlates of the OPD-SQ. Within the default mode network, the OPD-SQ main score was found to highly correlate with the precuneus, which plays a crucial role for the self and self-consciousness. Specific OPD-SQ dimensions showed high correlations with multiple regions, like the superior parietal lobe and the insular cortex with self-regulation or the left middle frontal gyrus with regulation of relationships. Connecting the OPD-SQ dimensions with the aforementioned CMS model proved more challenging. Nevertheless, being one of the first resting-state study to investigate ego-functions, our approach and obtained results prove to be a promising starting point for future research.

## **Subtyping early psychosis patients with tensor analysis of EEG**

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Psychiatric diseases pose many challenges due to their complexity and heterogeneity at levels spanning genotypic, pathophysiologic, and phenotypic. Quantitative assessments of abnormal brain activity correlating with the major clinical symptoms and signs of a given nosological entity may have relevance to patients' stratification and early detection. In early psychosis, neural activity during low-sensory processing has been shown to be impaired as compared to healthy control. Yet, whether these different brain patterns are coupled with different diagnostic labels or symptom dimensions remain unclear. Here, we recorded auditory (oddball standard and deviant) and visual (Kanizsa-type illusory contour and non-illusory contour) event-related potentials (ERPs) from a large sample of early psychosis disorder patients (N=76) and age-matched healthy controls (N=95). Significant ERP differences were observed between patients versus controls. Specifically, early-latency auditory and visual ERP responses were reduced in amplitude in patients, supporting previous findings. By using tensor decomposition of the ERP signals, temporal, topographical and subject scores were jointly extracted. Interestingly, these features captured the main population differences found with ERPs analysis. We then applied multivariate partial least squares (PLS) correlation analysis to the obtained subject scores of the four conditions (two auditory and two visual stimuli) and the positive and negative syndrome scale (PANSS). The PLS correlation analysis exploited the combination of the diagnosis subtypes, symptomatology, and ERP signals to reliably differentiate affective versus non-affective early psychosis patients. These combined results support the use of EEG evoked potentials as biomarkers to stratify psychiatric patients.

### **Personality at Rest, Replicating the BIG 5 in the Default Mode Network**

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The exact description and measurement of personality has been and still is a major challenge to the greatest minds. The development of modern neuroimaging techniques allowed not only for a more profound understanding of personality, it also enabled the description of functional networks and brain structure associated with specific aspects of personality. By using functional magnetic resonance imaging (fMRI), this study aims at elucidating and further explaining the neural basis of the Five-Factor personality dimensions within the Default Mode Network (DMN). In this fMRI study, 90 healthy participants underwent a resting-state with eyes open. Afterward, a test battery, which most importantly provided a widescale assessment of personality (NEO-PI-R), was administered. Functional image data were analyzed using a seed-based functional connectivity approach, with seeds within the frontal (MPFC) and posterior (PCC) part of the DMN. Multiple regression analyses were performed to determine the neuronal reflection of the three personality dimensions Neuroticism, Extraversion and Openness within the resting-state. Surpassing previous studies, here not only the dimensions of personality, but also their facets were examined for possible neural correlates. Our results indicate a broad neural base of Neuroticism (anterior cingulate cortex, right medial temporal gyrus), and Openness (precuneus, right inferior frontal gyrus). Moreover, most of the dimensions' facets were also found to show significant neural associations. Our findings further strengthen the notion of a strong neural basis of personality within the resting brain. This neuronal basis was not only found for global factors but also for the more detailed and extensive single personality facets.

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#### **How the ageing brain reacts during and after the exposure to others' suffering**

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Social emotions such as empathy have been widely studied in young adults. Conversely, empathy-related brain functions in older adults are poorly understood. In addition, most of the studies in younger adults focused on static - rather than dynamic- aspects of empathic responses. The goal of the current study is to assess whether exposure to other people's suffering produces sustained carryover effects on the activity and connectivity of emotion network in the brain of older adults. We acquired functional resonance imaging data while 127 participants over 65 year-old watched emotional video-clips from the Socio-affective Video Task (SoVT) followed by rest periods of 90 seconds. Participants also provided self-report on their feelings in response to each video as well as measures of empathy, anxiety, and emotion regulation. Elderly participants reported higher empathy and negative feelings, as well as lower positive feelings in response to others' suffering compared to everyday life situations. Witnessing others' suffering induced greater brain activity in areas related to empathy and social cognition. During the 90 seconds of resting state after exposure to videos, we observed increased activations in brain regions related to the default mode network as well as different connectivity patterns, following the emotional relative to the neutral videos. Our study shows that when faced with others' suffering, older adults experience stronger emotional states, with concomitant changes in brain activity that persist over time even at rest. These effects reveal carryover effects of emotional episodes into subsequent periods and modulation of resting state activity by emotional information.

## **Specific and generic features of facial expressions of pain and disgust**

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Pain inadequate treatment is frequent in modern society, leading to major medical, ethical, and financial implications. In many healthcare environments pain is quantified prevalently through subjective measures, such as self-reports from patients or health care providers' personal experience. Recently, automatic diagnostic tools have been developed to detect and quantify pain more "objectively" from facial expressions. However, it is still unclear if these approaches can distinguish pain from other aversive (but painless) states. In the present study, we analyzed the facial responses from a database of video-recorded facial reactions evoked by comparably-unpleasant painful and disgusting stimuli. We modeled this information as function of subjective unpleasantness, as well as the specific state evoked by the stimuli (pain vs. disgust). Results show that a machine learning algorithm could predict subjective pain unpleasantness from facial information, but mistakenly detected unpleasant disgust, especially in those models relying in great extent on the brow lowerer. Importantly, pain and disgust could be disentangled using an ad hoc algorithm that relied on combined information from the eyes and the mouth. Overall, the facial expression of pain contains both specific and unpleasantness-related information shared with disgust. Future automatic diagnostic tools should be guided to account for this confounding effect.

## **Early human amygdala responses to subliminal fearful but not angry faces**

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Despite evidence for subliminal processing of emotional faces in the human amygdala as supported by various neuroimaging methods, the involvement of this subcortical nucleus in non-conscious emotion processes remains controversial. Most crucially, the precise temporal dynamic of amygdala responses to subliminal and supraliminal information remains fully unknown. In this study, we used intracranial electroencephalography recording in seven patients with depth electrodes in the amygdala to probe for the neural response latencies associated with conscious and non-conscious emotional processing of faces. Participants were presented with faces (Fearful, Angry, or Neutral expressions) during a Continuous Flash Suppression task. We report specific and robust response to subliminal Fearful (vs Neutral and vs Angry) faces that started with an early onset (< 40ms) and extended over a shorter time-windows (until ~320ms) post stimulus-onset, as compared with supraliminal perception (starting at 200 ms and lasting until ~800ms). In contrast, amygdala responses to Angry and Neutral faces did not significantly differ. These results suggest that the amygdala may be distinctively sensitive to emotional signals from face expressions associated with fear, at least in the context of a detection task, and additionally point to distinct processing stages that are engaged at different latencies depending on stimulus awareness. Remarkably, earlier but shorter responses were observed for non-conscious Fearful faces relative to previous findings with intracranial electroencephalography when Fearful faces were consciously perceived. Thus our novel results shed light on the temporal dynamic of amygdala responses to emotional face information during non-conscious and conscious perception.



## **Multiple forms of outcome representations in human Pavlovian conditioning**

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A common symptom across many clinical conditions, such as drug addiction, is the willingness to go to extraordinary lengths in order to obtain an object of desire, even though once obtained the object is not experienced as pleasurable. What are the mechanisms that make the human brain vulnerable to situations where choice behavior is hijacked in the service of outcomes that are not valued by the individual? To address this question, we conducted a series of studies combining classical experimental paradigms developed through the study of animal behavior (i.e., Pavlovian conditioning), with eye-tracking and functional imaging techniques. During Pavlovian conditioning, participants generated a set of conditioned responses to a conditioned stimulus that predicted the subsequent delivery of an affectively significant outcome, namely food. Our results suggest that Pavlovian conditioning involves two distinct types of learning processes: one that learns the value of the outcome, and one that learns the sensory properties of the outcome. These learning processes are underlain by distinct neuronal networks and generated multiple and parallel conditioned responses. Strikingly, these conditioned responses had different sensitivities to outcome devaluation: Pavlovian responses based on the representation of the outcome's value flexibly adapted to outcome devaluation, whereas Pavlovian responses based on the sensory properties' representation were resistant to outcome devaluation. These findings shed some light on the mechanisms underlying Pavlovian conditioning and provide new insights into the understanding of persistent reward-seeking behaviors when the reward is no longer valued by the individual.

### **Developing a Dynamic Causal Modeling of the network governing dynamic emotional expressions**

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Dynamic Causal Modeling (DCM) is a method to estimate effective brain connectivity at the network level based on Bayesian Model Selection (BMS) and allows for direct testing of the strength and direction of interactions between regions of interest (ROIs). We used DCM to define the functional organization of the human face perception network during the processing of dynamic emotional expressions. A novel temporal face composite paradigm was given to 24 participants undergoing fMRI while they rated the intensity of four (Anger, Happiness, Sadness and Joyfulness) emotional face expressions, in which the motion of internal features unfolded either globally (synchronously) and locally (asynchronously). Our DCM results suggested a direct reciprocal interaction between Inferior Occipital Gyrus (IOG) and Fusiform Gyrus (FG) across both global and local motion conditions, but preferential engagement of the IOG and the posterior Superior Temporal Sulcus (pSTS) pathway with asynchronous expressions. DCM analysis further showed that asynchronous expression features engaged a differential information flow, centered on pSTS, which received direct input from IOG and projected to the amygdala. Moreover, pSTS and the amygdala displayed selective interactions with ventral Anterior Cingulate Cortex where the integration of both local and global motion cues (present in synchronous expressions) could take place. These results provide new evidence for a role of both local and global temporal dynamics in emotional expressions, extracted in partly separate brain pathways. This study also illustrates a detailed step-wise methodology for developing DCM models from the selection of ROIs through to a construction of network architecture tested in the BMS framework and comparing functional connectivity across conditions.

### **Stress, honesty, and rewards: Investigating if and how stress impacts compliance with moral codes of conduct**

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This study examines how stress influences decision-makers faced with a tradeoff between increasing their self-interest (cheating) and doing what is appropriate from a moral standpoint (being honest). Stress alters neural function and behavior by: 1) enhancing neural sensitivity to immediate rewards in the ventral striatum and 2) decreasing the engagement of brain areas involved in response inhibition and goal selection, particularly in the ventromedial and dorsolateral prefrontal cortex. When immediate rewards are self-achievable via cheating, stress could impact honesty by: 1) increasing dishonesty through making the reward more attractive, 2) leading to more habitual behavior by reducing self-control, thereby making people who assign higher/lower values to honesty less/more likely to cheat in order to increase their earnings. Stress will be induced using the Montreal Social Imaging Task followed by three tasks measuring honesty and three control tasks. We will test behavioral and neural processes determining the impact of stress on honesty, combining fMRI with psychophysiological (heart rate, skin conductance and saliva) measures of stress and psychometric tests determining subjects' protected values for honesty. Behaviorally, we predict that subjects' moral preferences will mediate the effect of stress on honesty; high/low moral value individuals will become more/less honest when stressed. Neurally, we expect stressed individuals (vs. baseline) to show decreased engagement of the ventromedial and dorsolateral prefrontal cortex in the honesty tasks. However, we expect high/low moral value individuals to show a decreased/increased functional coupling of the ventral striatum with the ventromedial prefrontal cortex, explaining the predicted behavioral effect of stress on honesty.

### **Using Video Games in Emotion Research**

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Video games have a huge potential in emotion research due to their versatility and first-person perspective. Unlike conventional stimulation methods such as pictures and movies, the interactive aspect of video games enables the execution of goal-directed actions and direct experience of their consequences. This may therefore constitute powerful tools to evoke strong emotions and provides a richer set of behavioural measurements including the assessment of motivation and action tendencies. Coupled with the fact that video games can be custom-made to carefully select and manipulate variables of interest, these features are particularly interesting in the framework of appraisal theories. Appraisal factors (e.g. goal conduciveness, uncertainty, etc.) can be manipulated such that combinations of different appraisals elicit different emotions in each individual. Moreover, in the context of brain imaging, the continuous nature of video games constitutes a precious tool for studying temporal dynamics of brain networks during emotional processing. However, although variability in game experience due to different playing strategies across participants has its advantages, it can also complicate data analyses and careful controls need to be introduced to assure interpretability of the manipulated variables. Here, we provide an implementation example that takes into account these limitations and balances a trade-off between having longer gameplays to elicit certain emotions, and having adequate sample size for each condition. Overall, through careful considerations of the intricacies of using video games in experiments, we believe that emotion research stands to gain from these richer and more stimulating environments.

#### **Are you laughing at me? Neural correlates of social intent attribution to auditory and visual laughter**

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**Introduction:** Laughter is a powerful social signal. It can express social acceptance or rejection. Here, we addressed the neural correlates of social intent attribution to acoustic or visual laughter within an fMRI study.

**Methods:** Fifty two healthy participants (27 women, age  $29.2 \pm 9.5$  years) were asked to rate various laughter sequence (60 acoustic, 60 visual, 1.5s each) as positive versus negative in intent on a four point scale. FMRI-measurements (3T PRISMA, 72 slices, thickness mm, TR 1,5 s, TE 34 ms) were analyzed using SPM12.

**Results:** Although the visual and acoustic stimuli were created from identical laughter recordings, significantly higher percentage of positive social intent attribution was found for visual stimuli. Regarding neural correlates, negative social intent attributions were associated with activation increases within the medial prefrontal cortex (mPFC/ACC) for both modalities. Additionally, modality specific correlates of negative attributions were localized within bilateral inferior frontal gyrus and right superior temporal gyrus (STG) for visual laughter and bilateral STG for acoustic laughter without overlap across modalities. Moreover, positive social intent attributions were linked to hemodynamic responses within right inferior parietal and dorsolateral frontal areas without overlap across modalities.

**Discussion:** In line with previous studies, visual laughter elicited a positivity bias as compared to acoustic laughter. Increasing activation within the mPFC/ACC linked to negative intent attributions in both modalities corroborates the role of this area for processing social rejection. Otherwise, the findings indicate that neural correlates of social intent attribution to auditory and visual laughter are located in neighboring, but spatially distinct neural structures.

## **When do Neurophysiological Correlates of Word Production change in the adult Lifespan?**

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Language is one of the most preserved cognitive functions in ageing. Yet, age-dependent differences in word production performance can be observed in both accuracy and production latencies (Kavé et al., 2010). Neurophysiological activity underlying word production has also been shown to vary between young and older adults, word production modifications being influenced by age-related changes (Valente & Laganaro, 2015). As studies usually compare groups of young adults (20-30) to older adults it is unclear when such changes occur in the lifespan. In this study we aimed to investigate the electrophysiological (EEG) and event-related (ERP) patterns underlying word production in a picture naming task, not only between the two extremities of the adult lifespan, but including intermediate age-groups and adolescents. High-density EEG was recorded on 120 French native speakers aged 14 to 80 years-old divided into six age-groups. Behavioral results show that only the participants of the oldest group (70-80) display slower production latencies relative to the other groups. By contrast, ERP microstates differ in adolescents and young adults as compared to all other older groups in a time-window associated to lexical-semantic processes (after the P1 component). Hence, distinct behavior is observed only in the oldest group of adults, while a different pattern appears in the neurophysiological data with the three youngest groups differing from all other groups. This unforeseen pattern may reflect the ongoing maturation of young adults' brain wiring (Lebel & Beaulieu, 2011). Thus, it questions the relevance of investigating mental processes mostly with undergraduates (20-30 years old).

## **Effects of Text Difficulty during Natural Reading**

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We conducted a co-registered eye-tracking and fMRI experiment to examine how global text difficulty influences eye movements and neural activation during natural reading. Forty participants read forty paragraphs representing a wide range of difficulty levels (assessed using Flesch-Reading-Ease scores) in the scanner while their eye movements were recorded. Each paragraph was presented for twelve seconds. Eye tracking results showed robust relationships between text difficulty and online reading measures: As texts became more difficult, readers had longer fixation durations, shorter saccadic amplitudes, and slower reading rates (measured in words per minute). These results suggest that eye movement behaviors are sensitive to objective measures of global text difficulty. fMRI results demonstrated that there were strong negative correlations between text difficulty and activation in language-related areas such as bilateral superior temporal gyrus/sulcus, bilateral angular gyrus, right middle temporal gyrus, and right inferior frontal gyrus (pars triangularis), suggesting that deeper semantic networks are involved when readers process easy texts compared to difficult texts. In addition, activations in right superior frontal gyrus, right calcarine sulcus, left middle occipital gyrus, left lingual gyrus, and left amygdala were also negatively correlated with global text difficulty. However, global text difficulty was positively correlated with brain areas such as bilateral posterior cingulate gyrus, bilateral precuneus, and left dorsal angular gyrus, demonstrating that these regions were more active when the text was more difficult to understand. Overall, the results suggest that patterns of eye movements as well as brain activation are sensitive to changes in the global difficulty of texts.

## **Is dog cortical entrainment affected by speech rate and type? A comparison with human processing**

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Processing speech requires segmenting a continuous acoustic flow into building blocks that connect with stored linguistic representations. Our auditory cortex is able to track structures in speech using the rhythmicity of neuronal ensembles, which tend to fire in synchrony, in bilaterally distributed but functionally lateralized cortical systems. Speech comprehension fails when speech rate is compressed beyond its natural range and this effect is correlated with decreased coherence between the speech envelope and cortical oscillation. Dogs are phylogenetically distant from humans, yet our long coevolutionary history has likely favored their unusual ability to perceive and respond to human signals. They can learn >1000 words naming objects, treating them as verbal referents, and dog speech processing appears to exhibit functional lateralization analogous to ours. Despite these striking similarities with humans, we do not know how dogs process speech. In this study, we will investigate how dogs' cortical oscillations entrain to speech and whether this entrainment is influenced by speech rate, prosodic structure and familiarity. Behavioural tests will allow us to assess how entrainment correlates with dogs' "comprehension" of speech. Understanding whether and how dogs track and syllabify continuous speech and where the bottleneck for speech comprehension lies will ultimately help us inform our models of human linguistic communication evolution. We present the current state of the development of the project.



## **Neural correlates of overt, covert, and perceived speech: critical differences and exploitable features for decoding.**

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Current research initiatives aim to use brain activity elicited during the imagination of speech as a proxy to reestablish communication in people who have lost motor capabilities. The main difficulties in this endeavor are: high variability observed in brain signals during imagination of speech production across repetitions of the same utterance, lack of behavioral output, inter-subject variability, and reduced amount of data available. In this work, we present a comparative analysis of neural correlates of speech during three different tasks: listening, covert, and overt production using spectro-temporal features from electrocorticographic recordings. Also, we tested whether the usually assumed similarities in broadband activity between covert and overt speech lead to significant discriminant scores among different words produced by the subjects. Results show a reduced involvement of broadband activity in covert compared to listening and overt production. However, strong low-frequency component modulations were present in the three tasks. In terms of decoding, our results show that broadband modulation, while highly discriminant in the case of perception and overt production of speech, does not provide significant information for effective decoding in the case of covert speech. These results should, however, be taken cautiously as the lack of substantial broadband modulations in covert speech could be partially caused by latencies in the task execution across trials, which cannot be controlled using behavioral output. On the other hand, low-frequency components are related to slow variations of amplitude, making it less sensitive to latency but lack the ability to reflect details of processes at higher temporal scales.

### **Theta-gamma coupling coordinates predictive processes during speech perception**

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Speech perception is a complex process involving neural oscillations in different timescales and hierarchically organized brain areas. Specifically, theta and gamma coupled oscillations can segment continuous speech into syllable-like units and organize gamma range activity into decipherable neural code. Speech comprehension also strongly relies on top-down predictions derived from knowledge about speech content and structure. Predictions are updated based on bottom-up prediction errors, which might be communicated by gamma oscillations. Here, we designed a generative model that can recognize syllables in a natural, continuous speech signal and that unlike previous versions, is able to process the variable syllable duration in natural sentences. With this model, we explore how theta-gamma coupling organizes top-down and bottom-up dynamics during speech processing. The model uses theta oscillations to signal syllable onsets and duration to align 1) gamma-rate activity with syllable boundaries and 2) predictions with speech input. Model simulations showed that the best performance was obtained when theta-gamma coupling was used to align gamma activity with input syllables and internal knowledge about the spectral structure was used to reset accumulated evidence about inferred syllables, i.e. when bidirectional information flows were coordinated, and internal spectral knowledge was exploited. In a broader sense, our results indicate that notions of predictive coding and neural oscillations can usefully be brought together to account for dynamic on-line sensory processing.

## **Melodic Intonation Therapy For Aphasia: A Meta-Analysis**

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Longstanding neurological evidence shows that non-fluent aphasics can sing the words they cannot speak. One widely-used therapeutic strategy based on this observation is Melodic Intonation Therapy (MIT; Albert et al., 1973). MIT uses melodic aspects of language to restore propositional speech: patients repeat melodically intoned phrases while rhythmically tapping their hand. MIT might exert its effect by activating RH's language potential and/or engaging preserved LH language regions, possibly tapping into neural networks shared between music and language (Patel, 2003). The contribution of MIT's components (melody, rhythm, synchronicity) has not been investigated systematically, and interventions vary widely with respect to important features. We searched for studies on the main online databases, and sent requests for unpublished data to aphasia and music therapy organisations. Our final dataset included N=23 primary empirical studies, data from which were extracted by independent coders. The I<sup>2</sup> statistic was calculated a posteriori, to estimate between-trial heterogeneity. Outcome measures distinguished between speech production and language expression, as measured pre-&post-treatment using validated and standardised aphasia tests. Months-post-stroke-onset, treatment duration, and patient age were used as moderators. Preliminary results suggest MIT primarily benefits expressive language over other assessed outcomes. Despite great heterogeneity in primary empirical studies, a moderate effect size emerges. Case series dramatically overestimate the effectiveness of MIT, despite absence of publication bias evidence. No moderation effects were found at this stage, however further moderators are being considered, including lesion site and aphasia type.

## **Spatio-temporal organization of covert speech**

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More than 5 million persons in the world suffer from a strong speech disorder, often following brain strokes, but also in case of severe tetraplegia, locked-in syndrome, neurodegenerative disease such as amyotrophic lateral sclerosis or Parkinsons disease, myopathies, or coma. The elaboration of rehabilitation strategies using brain-computer interfaces (BCIs) to help these patients to restore speech functions require the decoding of cortical ensemble activity underlying speech imagination (covert speech). The extent of the neural network supporting representations of inner speech is still unknown, as it only partly overlaps with the speech production system. We used intracranial EEG recordings during overt and covert speech tasks performed by people with epilepsy to delineate the brain regions involved in covert speech. We show that the inferior frontal gyrus activates during speech processing, in particular in the lower beta and high gamma frequency bands. Before performing analysis in the temporal domain for covert speech, one difficulty is to precisely mark the onset of the event. We introduced a method to realign overt and covert neural signals when using more than two trials, and used it to demonstrate how high gamma activity in the lower frontal gyrus mark the onset of produced or imagined syllables. Our results provide new tools to select frequency bands and cortical regions involved in covert speech, that can be used as features in covert speech decoders and ultimately for BCIs, while shading new lights on the temporal processing of covert speech.

## **Neuronal activity reflects the perceptual fate of auditory and visual stimuli in naturalistic speech**

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Natural speech is a combination of continuous streams of auditory and visual inputs. The cerebral representations of auditory and visual speech cues, and their eventual influence on perception, are incompletely understood. The “McGurk effect” refers to situations where mismatched visual and auditory speech cues influence the receiver’s perception of what is being said. In one such effect, pairing a labiodental fricative viseme (the shape of the lips uttering “v”) with a bilabial occlusive phoneme (the sound of the consonant “b”) causes the receiver to perceive “v”: the visual cue overrides the auditory one. McGurk stimuli are typically presented as meaningless syllables that hardly reflect realistic audiovisual speech. Here, we designed an innovative experiment using 3D-animated avatars with realistic lip movements synchronized on computer-generated speech. We built sentences where the mismatching of one viseme with respect to the corresponding phoneme could turn one word into another, without any semantic violation. First, we optimized the incidence of the effect by varying background auditory noise and audiovisual lag in 24 participants. Second, we recorded high-density electroencephalography in another 14 participants. Crucially, in the case of visual “v” and auditory “b”, perception was dominated by either the viseme or phoneme in around 50% of trials. Perceptual differences were associated with differences in neuronal activity over left temporal electrodes between 50 and 100 ms after the presentation of the mismatched cue. Our experimental design represents a promising approach to study the neuronal representations of auditory and visual speech.

## **Speech-neural entrainment deficit in Autism Spectrum Disorder children**

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Autism spectrum disorder (ASD) is a neurodevelopmental disorder with impaired social communication, including speech-related information processes. Previous studies highlight the abnormal response to finite speech segments either in ASD adults or in children relative to typically-developing (TD) peers rather than their neural response to continuous speech. We hypothesize that ASD deficits in processing speech may result from poor neural entrainment to track speech dynamic structure, especially at stimuli-related syllabic-rate bands. To address it, we recorded EEG activity of 21 ASD children and of 26 age-matched TD toddlers while they were passively exposed to the naturalistic-continuous speech. Using a Multiple Linear Regression Model with distributed lag to reconstruct the speech stimuli from the corresponding EEG to detect the neural responses to stimuli, we found, ASD children displayed a significant reduction in the stimuli reconstruction accuracy metric relative to the TD peers. We used power analysis to test whether the ASD neural entrainment to speech dysfunction. Our results showed that ASD toddlers displayed a significant power reduction at stimuli-related syllabic-rate band (4-6Hz). Then we tested whether neural entrainment to speech develops with age and if it corresponds to participants' ability to process linguistic input. Results showed that the brain signal power in ASD toddler is negatively correlated with age and positively correlated with receptive language scores. The study provides evidence about the alteration in the neural mechanisms tracking speech in ASD children at specific frequency band associated with speech modulation and indicates the probability of neural entrainment as an index to predict language development.

## **Greater brain signal variability under load is a hallmark of faster, network-integrated, dopamine-elevated older adults**

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The study of brain signal variability in relation to human aging and cognition continues to gain momentum in cognitive neuroscience, often revealing that higher variability is typical of younger, better performing adults. Although mechanisms remain understudied, dopamine is gaining traction as a candidate neurochemical basis for dynamic, effective brains. However, we know little of how dopamine confers variability-based advantages for brain function, neither at regional nor network levels. Using data from the COgnition, BRain, and Aging (COBRA) study (dopamine D2 binding (PET), fMRI during n-back; N = 162, 64-68 yrs) and multivariate modeling, we show that greater working memory load-related increases in BOLD signal variability (SDBOLD) within “local” regions of the striato-thalamic system reflect: (1) elevated dopamine, (2) faster working memory performance, and (3) heightened load-related striato-thalamic functional integration (i.e., lower dimensional functional connectivity). We further show that striato-thalamic functional integration accounted for load-related shifts in SDBOLD in all other major networks examined (e.g., default, frontoparietal control, and dorsal attention networks), highlighting the central role of the striatum and thalamus in understanding moment-to-moment fluctuations throughout the brain. Our work suggests that rather than considering variability simply as a source of local “noise” that corrupts neural communication, the ability to elevate brain signal variability under load may instead be considered a joint hallmark of increased functional connectivity, better performance, and higher dopamine levels in older adults.

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## **Processing of the absence of expected outcomes depends on their behavioral relevance**

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Extinction capacity denotes the ability to learn that an anticipation is no longer valid. It serves to adjust behavior in a changing environment. Such adaptive choice appears when the identity of received outcome differs from expectation. Previous studies related the central role of the OFC to monitor this discrepancy and adapt the behavior accordingly. However, it's unclear whether the OFC activation depends on the unexpected outcome's identity itself or rather on the behavioral relevance of such absence. To evaluate the influence of outcomes' identity and behavioral relevance, we developed a modified reversal learning paradigm in which contingencies reversed after a subtle or an obvious change of the outcome's identity. We hypothesized that the behavioral relevance is a more important driver of OFC activation in response to the absence of an anticipated outcome than its physical identity. Twenty-four healthy volunteers underwent a high density EEG while they performed the reversal learning task. Behaviorally, participants made the correct choice in 97.66 % of trials. They persisted in their behavior only in 6.99 % of the time and erroneously changed their behavior 1.16 % of the trials. Obvious and subtle change in the expected outcome's identity evoked a specific electrical signal at 200 – 300 and 400 – 600 ms, only when the absence was behaviorally relevant. The present study demonstrates distinct brain responses depending on whether absence of expected outcome's identity indicates a need to adapt behavior or not.



## **Effects of acute physical exercise on associative memory in individuals with genetic risk for Alzheimer's disease: Preliminary findings**

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Alzheimer's disease (AD) is a neurodegenerative disease characterized by progressive memory and neural plasticity loss, affecting the hippocampus and neighbouring entorhinal cortex. The major genetic risk factor for the common late-onset form of AD is the APOE (apolipoprotein E) gene  $\epsilon 4$  allele (carried by 20% of the population), while the most common  $\epsilon 3$  allele (60% of the population) seems to be neutral with respect to AD. Recently, several lifestyle factors have been identified as possible regulating or therapeutic factors, which may influence the onset and progression of the disease. Among these, physical activity emerges as a highly relevant variable to be investigated. Indeed, regular physical exercise improves memory functions by increasing neural plasticity in the hippocampus, where neuronal loss due to AD appears first. Here we tested the effects of a single session of medium-intensity physical exercise on declarative memory in two groups of healthy young participants, one at high genetic risk of developing AD (APOE-  $\epsilon 4$  carriers) and one at low genetic risk ( $\epsilon 3$  homozygous). So far, we tested 18 high-risk and 17 low-risk participants in a within-subjects design comprising one exercise and one rest visit. During each visit, participants performed the encoding part of an associative memory task in the morning, followed by the exercise or rest session, after which participants had to retrieve easy and more difficult associations. All memory sessions were performed in the fMRI scanner. Preliminary results showed a clear effect of task difficulty, but so far no effect of genotype or sport, and no interaction.

## **Self-identification modulates grid-cell like representations during virtual navigation in humans**

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The discovery of grid cells encoding allocentric self-location has greatly contributed to understanding spatial representation in the brain. Their hexagonal grid-like field maps are maintained in darkness and persistent to landmark changes, suggesting that self-motion cues are providing a crucial input to grid cells. In this study, we assessed whether they reflect changes in bodily self-consciousness (BSC), an aspect of self-consciousness that processes and integrates the multisensory bodily signals. Self-identification (i.e. ‘which is my body’) is a key component of BSC and, notably, recent studies showed that illusory changes in self-identification not only alter experienced self-location but also affects self-related spatial cognitive processes such as size perception. Based on these, we hypothesized that changes of BSC may affect grid cells through self-relevant processes. To assess the influence of BSC on grid-cell in humans, self-identification was systematically manipulated by presenting a self-identified avatar in the scene while participants navigated in a virtual arena. We used the measure of heading direction-dependent BOLD signal changes in the entorhinal cortex as a proxy for the activity of grid cells (i.e. grid cell-like representation). As a result, we found that the self-identified avatar embedded in the scene disrupted grid cell-like representation, which was significant in the absence of the avatar. Conjointly, we found higher activity in the posterior parietal cortex suggesting increased egocentric processing of navigational cues when the avatar was presented. Taken together, our results suggest that BSC modulates the involvement of allocentric grid-like computations and egocentric bodily processing during virtual navigation.

## **Sleep improves distinct behavioral and electrophysiological aspects of sequence learning**

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To efficiently interact with the outside world, the brain appears to use internal models that represent regularities in our environment. Since such internal models are based on previous experience and sleep is known to support memory consolidation, we hypothesized that sleep consolidates newly encoded spatio-temporal regularities to support predictions of future events. Employing a contextual-perceptual sequence learning paradigm, we recorded behavioral performance and high-density EEG during task performance before and after a night of sleep or wakefulness. Behaviorally, we find longer reaction times for unpredictable sequences after sleep compared to wakefulness when and only when stimuli contain a behaviorally relevant perceptuo-motor component. Electrophysiologically, we observe increased amplitudes of attention-sensitive event-related potentials (ERPs) N1 and N2 for random vs. structured blocks after sleep. In contrast to behavioral performance, these ERP effects were specific for purely perceptual sequence learning. Moreover, occipital fast spindles were correlated with behavioral performance after the retention period in the sleep group. Taken together, our results suggest sleep spindle-dependent improvements in implicit sequence learning, potentially related to visual cortex reactivation during sleep and a subsequent reduction of attentional resources required to process known spatio-temporal sequences.

## **Confidence in economic decisions is biased by learnt action values**

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Accurately estimating confidence in one's choices being correct is important for evaluating and adapting strategies. However, confidence is biased: for the same objective difficulty, people are more confident when seeking gains than when avoiding losses, while maintaining the same accuracy. We recently showed how this pattern could be explained by the sum of 1) a context-dependent learning mechanism (considering outcomes on a relative scale centered at the learnt average value of the context), and 2) a confidence calculation biased by the learnt context value. Here we test this idea against different alternative models of confidence, some of which would not require contextual learning. We use data from five experiments (N = 90) in which humans took part in a two-alternative instrumental learning task and a transfer task (where options appeared out of their original context and without feedback). During the learning task, context valence (losses vs gains at stake) and information completeness (feedback about the unchosen option present vs absent) were manipulated. We test combinations of learning models (context-dependent vs independent) and confidence biases to account for confidence reports. We find that 1) contextual models offer better predictions of individual confidence reports, 2) confidence is biased by the learnt value of the chosen option, and 3) in the learning task, confidence depends on both objective difficulty (difference in learnt values of the options) and bias, whereas in the transfer task the effect of difficulty becomes negligible.

## **Time course of encoding and recognition in the human medial temporal lobe**

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The medial-temporal lobe (MTL) is crucial for encoding novel information, but may also be involved in memory retrieval and recognition. The time course of these processes is unknown. Recent evoked potential studies suggested that MTL-mediated encoding may be an early process, occurring 200-300 ms after stimulus presentation. In the present study, we juxtaposed encoding and recognition in a single continuous recognition task (CRT) with meaningful designs. 20 healthy subjects performed a CRT containing New stimuli (New), thought to induce novelty detection and encoding, which were then repeated up to 4 consecutive times (Rep-X trials), a procedure devised to produce an over-familiarity with the stimulus. These stimuli later reappeared after 9 to 15 intervening items, thus requiring recognition (N-back trials) and presumably inducing re-encoding. Differences in evoked response potential (ERP) amplitudes and in spatiotemporal dynamics were observed in response to the 3 stimulus types in the early (145-205 ms), intermediate (210-280ms) and late (410-470ms) periods. Neural source estimations revealed more extended MTL activations for New and N-back stimuli compared to Rep3 items in the early phase, indicating an encoding process in this period. In the later time window N-back, in comparison to New items induced increased activity in the MTL, indicating that recognition occurs in this late period. These results suggest that encoding of stimuli's new occurrence is initiated before recognition of previously encountered material. The results complement earlier studies indicating rapid limbic influences on memory processing.

Keywords: Human MTL, Memory, Encoding, Recognition, ERP.

### **Reliable Independent Component Analysis to Disentangle Information from Noise in Mobile Brain/Body Imaging Settings**

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The ability to walk independently is fundamental for the execution of daily life activities. Brain injuries (e.g., Stroke, Parkinson's Disease) can cause locomotion impairment with a negative impact on the quality of life. Great effort needs to be taken into restoring walking in people with brain damage. In order to get a deeper understanding of cortical involvement during walking it is necessary to develop models that represent cortical activities in relation to human walking patterns. It is known that the cortex proactively controls voluntary and precise movements and is involved only in "high-level" motor planning (e.g., gait initiation, addressing obstacles, etc.). Its involvement during ambulation tasks however is only hypothesized because of the limits of available imaging techniques. Here a novel approach based on reliable Independent Component Analysis (RELICA) was used to verify the feasibility of disentangling information from noise in three Mobile Brain/Body Imaging (MoBI) experiments, which integrated High-Density electroencephalogram (EEG), electromyogram (EMG) and kinematics during walking respectively (i) on a treadmill, (ii) on a treadmill with the Lokomat exoskeleton and (iii) overground with the Ekso exoskeleton. In all cases it was possible to clearly separate Independent Components related to brain activity from physiological artifacts such as neck muscle activation, blinks, lateral eye movements and eyes bobbing. In some cases it was also possible to identify heart activity, line noise and even movement-related mechanical artifacts. The results prove the feasibility of using MoBI paradigms even with exoskeletons, to build the basic knowledge necessary to optimize rehabilitation protocols.

## **Synchronization modes and integration in the brain at rest**

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The brain is an integrated system visiting diverse cognitive states for allowing a flexible cognition. However, the mechanism underlying such behavior is under debate. In fact, when the brain is modelled as a metastable system operating in a criticality regime, an efficient integration is expected to be guaranteed by continuous temporal fluctuations among these connectivity states. However, a large evidence suggests that the integration relates also to the presence of functional hubs acting as waystations of integration at different frequency bands and diversified based on their spatial role or temporal dynamics. Thus, to relate the dynamics of functional hubs to the dynamics of integration it might provide the mechanism underlying the switching from one state to another. In this MEG study, we found that, analogously to the metastability concept, in terms of integration the brain visits few synchronization modes defined as clusters of functional hubs whose centrality is temporally aligned. These modes alternate over time and represent an efficient axis of integration across high order cognitive domains such internal cognition, executive control, somato-motor planning and attention. This mechanism is specific for the beta band and these modes showed a different spectral/temporal content and probability of transition among them. Notably, the brain integration seems highly vulnerable with respect to a simulated attack to this temporal synchronization mechanism. We used leakage corrected MEG resting state data where we analyzed the spontaneous temporal dynamics at 5 Hz based on a large dataset (110 resting state sessions).

## *Methods*

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### **A non-invasive method to explore animal's cognition: A proof of concept using brain lateralization in baboons**

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The emergence of non-invasive techniques such as functional near infrared spectroscopy (fNIRS), originally designed to investigate human brain processes, can be used in animal research to investigate brain functions in accordance with growing ethical considerations. We developed a proof of concept fNIRS study, testing hemispheric lateralization during two tasks in three olive baboons (*Papio Anubis*) that were anesthetized with a minimum amount of propofol in order to preserve cognitive treatments as much as possible. First, we performed a motor task with a block design during which right or left arm were passively stretched and stimulated twenty times. Second, we broadcasted 20 seconds of sounds (white noise, chimpanzee or baboon vocalizations) and 15 seconds of silence in alternation, either binaurally or only on one side during approximatively 12 minutes. As predicted, the preliminary results show a contralateral activity in the baboon brains depending on the arm or the ear stimulated (right arm and ear activated more the left hemisphere and vice versa comparing to the silences, the block intervals or the sounds played in stereo). To our knowledge, this study is the first as proof of concept to demonstrate the suitability of fNIRS to be used with nonhuman primates, allowing further studies to assess brain hemispheric laterality using motor and acoustic paradigms.



## **Fast HD-EEG with dry electrodes**

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Multichannel Electroencephalography (EEG) is widely used in clinical neurology and neuroscientific research. Wet Silver/Silver-Chloride (Ag/AgCl) electrodes represent the gold standard. Electrode-skin contact for these electrodes is ensured by electrolyte gel or paste. Skin preparation, gel application and subsequent cleaning require skilled personnel and extensive lab time especially in high-density setups with 128 or 256 electrodes. Dry electrodes represent an alternative for rapid EEG, eliminating skin preparation requirements and enabling self-application by the subject. We present novel HD EEG caps with dry electrodes. A new electrode design using smaller diameter and only 19 pins was developed based on our previous dry electrodes with up to 30 pins. Polyurethane serves as the substrate material and an Ag/AgCl coating provides electrical conductivity of these semi-rigid electrodes. We compare in a proof of principle study the novel dry HD-EEG cap with a conventional gel-based HD-EEG cap using a previously established validation paradigm. Both compared caps comprise identical, equidistant electrode layouts. Resting state EEG, eye movements, alpha activity, and pattern reversal VEP can be recorded with the dry electrode HD-EEG cap without considerable differences in signal quality compared to a conventional wet cap. For the dry EEG cap, we obtained an average channel reliability of >85 % and a reduction of the preparation time by at least 75 %. All volunteers reported good wearing comfort and favored the dry EEG cap. In conclusion, the proposed HD-EEG caps with dry electrodes can potentially replace conventional gel-based EEG caps and thus enable new fields of application like brain-computer-interfaces and mobile preparation-free EEG acquisition.

### **Functional Connectivity Fingerprints of the Pulvinar: Decoding its role in Human Cognition**

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The pulvinar is the largest thalamic nucleus in the brain and considered as a key structure in sensory processing and attention. Although its anatomy is well known, in particular thanks to studies in non-human primates, its role in perception and cognition remains poorly understood. Here, we used resting-state functional connectivity from a large sample of high-resolution data provided by the Human Connectome Project, combined with a large-scale meta-analysis approach to segregate and characterize the functional organization of the pulvinar nucleus. We identified five clusters per pulvinar with distinct connectivity profiles and revealed their respective co-activation patterns. Using the Neurosynth database, we then investigated the functional significance of these co-activation networks. Our results confirm the functional heterogeneity of the pulvinar, revealing striking differences across clusters in terms of connectivity pattern and their cognitive profile. While the anterior and lateral clusters are consistently involved in motor aspects of cognition, the ventromedian and dorsomedian clusters seem to be more closely linked to emotional processes. In contrast, the inferior cluster shows less specificity but correlates positively with both cognitive and perceptual processes. Collectively, our results suggest that the pulvinar is likely to integrate different components of cognition, thus supporting a central role in the coordination of cortical processes mediated by distributed brain networks.

## **On why correlation-based functional connectivity does not match structural connectivity**

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Understanding how brain anatomy shapes brain function is a complex question. Empirically, it has been observed that the strength of anatomical connections between brain regions, i.e., structural connectivity (SC), is to some extent reflected by the pattern of statistical dependences between brain function in different regions, i.e., functional connectivity (FC). In these SC-FC comparisons, FC is almost always evaluated from the correlation between functional time series. However, we argue that since correlation-based FC captures both direct and indirect (i.e., through mediators) statistical dependencies, it is not a metric of choice to explore the link with SC which by definition only captures direct connections. Therefore, in the context of SC-FC comparisons, we propose to evaluate FC using the precision matrix, defined as the inverse of the correlation matrix, because it captures only direct statistical dependencies between functional time series. Using functional and anatomical data from 100 unrelated subjects of the Human Connectome Project we show that provided a sufficient amount of functional data is available, the match between precision-based FC and SC increases by up to 100% as compared to correlation-based FC, while also allowing more meaningful SC-FC comparisons. We then illustrate how precision-based FC can be used to better characterize the nature of functional dynamics on the underlying brain anatomy at the whole-brain level and in the main resting-state networks.

## **Spatial gradient of structure-function coupling in the brain is behaviorally relevant**

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How brain function relies on the underlying structural architecture still represents an open question in neuroscience. Both pieces of information can be retrieved by different techniques of Magnetic Resonance Imaging (MRI), i.e. functional MRI and diffusion MRI, respectively. How to optimally integrate them has been recently investigated using sophisticated network science approaches involving graph signal processing. Here, we build upon this framework and introduce the *structural-decoupling index*, a regional measure quantifying structure-function relationship in each brain area. We defined this index on 100 healthy subjects from the Human Connectome Project (HCP). Structural connectomes, obtained from tractography and the Glasser parcellation (360 regions), are averaged together to a mean brain graph. On top of it, resting-state functional MRI timecourses extracted at the same parcellation nodes for each individual represent time-varying graph signals. The decomposition of functional signals into structural harmonics allows the subdivision of the functional activity into two portions, one most often coupled with the structure, and the other more decoupled. The ratio between these two portions yields the structural-decoupling index for every brain region. Different ways to filter the functional activity are explored and compared. The results show for the first time that the degree of structure-function coupling distributes along a gradient with specific behavioral relevance, with the activity in primary sensory regions highly coupled with the underlying structure and the one in higher-level cognitive areas more decoupled. Noticeably, these results mirror previous findings of several different brain features; e.g., genetic expression, temporal hierarchy and functional connectivity.

## **EEG source dynamics establish transient, zero-phase related large-scale networks during rest**

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Intrinsic brain dynamics co-fluctuate between distant regions in an organized manner during rest, establishing large-scale functional networks. We investigate these brain dynamics on a milliseconds time scale, while focusing on Electroencephalographic (EEG) source analyses in this work. The limited spatial resolution of EEG inherently leads to temporal dependencies between their source dynamics. Here, we correct for this leakage effect based on spatial, not temporal relations, which enables the analyses of synchronous, i.e. quasi zero-phase related, large-scale neuronal dynamics. In eighteen subjects during rest with eyes closed, we provide evidence that distant, homologous areas brain areas in the two hemispheres indeed co-fluctuate at zero time lag. These co-fluctuations we found to be metastable forming brief states ( $74.59 \pm 10.46$  milliseconds) of high global synchrony. Focusing on these simultaneous dynamics, we characterize large-scale functional brain networks by identifying their spatial configurations and the spectral profiles of their interactions. These networks are primarily composed of regions in prefrontal and parietal areas and showed specific spectral profiles for each network. In summary, we show that synchronous dynamics establish metastable states, which might be instrumental for integrating information within large-scale networks.

## **Impulsivity reduction during the Full-Body Illusion**

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The Full-Body Illusion (FBI) relies on multisensory conflicts to induce self-identification with a seen avatar. The FBI has been associated with changes in subjective body experience (e.g. self-localization in space, touch perception and pain perception), as well as with altered cognitive functions (e.g. semantic processing, biographical memory and social interactions). The present study investigates the effects of the FBI on decision-making and impulsivity. We hypothesized that the experimentally induced dissociation between the self and the physical body during the FBI might affect the valorisation of immediate and delayed rewards. Using a temporal discounting task, we assessed participant's impulsivity during the FBI (synchronous visuo-tactile stimulation) and during a control condition (asynchronous visuo-tactile stimulation). Two behavioural experiments (n1=16, n2=18) showed that the FBI is associated with reduced impulsivity. Using 3T fMRI and Dynamical Causal Modelling, we explored brain dynamics while participants performed the same task. We found that the dynamics of fronto-parietal networks, including the temporo-parietal junction, the intraparietal sulcus, the premotor cortex and the dorso-medial prefrontal cortex, were modulated during our experimental manipulations. In addition, preliminary data collected with patients suffering from frontal lesions and exhibiting high impulsivity suggests that this approach might be able to treat pathological impulsivity. These results extend our current knowledge about the complex relationship between subjective body experience and cognitive functions. Importantly, these results might lead to novel and simple approaches to treat impulsive behaviours associated with psychological and psychiatric disorders.

## **From statistical regularities in multisensory inputs to peripersonal space representation and body ownership: insights from a neural network model.**

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The Peripersonal Space (PPS) is the region of space immediately surrounding the body. Studies on primates described a network of multisensory neurons, dedicated to PPS representation, with visual or auditory receptive fields spatially anchored to specific body parts, and tactile receptive fields covering the same body parts. Neurophysiological and behavioural features of hand PPS have been previously formalized in a neural network model constituted by one multisensory population integrating tactile inputs with visual/auditory external stimuli, whose position was encoded in pre-computed hand-centered coordinates. Here we present a novel model, including a proprioceptive population encoding hand position, in order to account for the previously neglected reference frame transformations required to compute hand-centered coordinates. As a second novelty point, synaptic weights were spontaneously tuned to sensory inputs starting from random connectivity, under two minimal assumptions. First, we implemented a biologically plausible, Hebbian-like plasticity rule, designed to learn the natural statistics of sensory inputs. Second, we embedded the statistical regularities imposed by the body structure in visual, proprioceptive and tactile training inputs. The network learned to integrate proprioceptive and visual stimuli, and to predict tactile stimulation by computing their hand-centered coordinates. Through the same mechanism, the network reproduced behavioural correlates of manipulations known to alter subjective body ownership: the Invisible and the Rubber Hand Illusion. We thus propose that PPS representation and body ownership may emerge through a unified neurocomputational process: the integration of multisensory information consistently with a model of the body in space, learned from the natural statistics of sensory inputs.

## **Medial-lateral temporal cortex functional organization recruited for noise-free voice perception**

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The special sensitivity of the human superior temporal cortex for processing voices was rarely studied within the scope of realistic environmental conditions such as background noise. In the present project, we studied functional brain networks within and outside of the temporal voice areas (TVA) when participants processed voice and noise separately (study 1, N=98) and concurrently (studies 2 & 3, N=18 and N=20, respectively). Using fMRI, we observed the co-existence of within- and outside-TVA functional networks: coupled TVA functional connectivity (FC) and anti-coupled FC between the posterior TVA and the bilateral parahippocampus (study 1). We therefore hypothesized the co-existence of a ‘voice’ and ‘non voice’ or ‘noise’ brain networks, respectively. To formerly test this hypothesis and the extent to which each network would be relied upon to clearly perceive vocal signals in noisy environments, we designed a second task in which voice and noise were presented concurrently at varying intensities in a more realistic paradigm. At the behavioural level, voice perception was more difficult and took more time in high-noise as opposed to low-noise (study 2). Whole brain results emphasized the role of the posterior TVA in perceiving voices in highly noisy environments (study 3). Effective connectivity carried out using multivariate regressions pointed to the direct coupling of such regions with the parahippocampus when perceiving voices in highly noisy environments, while anti-coupling was observed in low-noise voice perception. Taken together, our data highlight medial to lateral posterior temporal cortex organization as a key contributor to clear human voice perception.



## **ERP correlates of consciousness and attention during perception of self-related stimuli**

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The main challenge in identifying the Neuronal Correlate of Consciousness (NCC) lies in distinguishing mechanisms of consciousness from mechanisms of concurrent attentional and cognitive processing. The P3b ERP component has been initially hypothesized to constitute NCC, but more recent studies show that it might be more closely related to salience and relevance of a stimulus. Considering that stimuli related to “self” capture attention and are processed preferentially we tested whether unconscious processing of such stimuli will generate the P3b component.

In the conducted experiment 3 types of stimuli were presented: subject’s own name, other name, or a blank (empty screen). Stimuli were displayed for 33 ms and followed either by a blank screen (supraliminal condition) or a backward mask (subliminal condition). In separate blocks participants (N=30) were asked either to rate subjective visibility of a word, or to identify a presented name. In conscious condition robust self-preference effect - defined as greater P3b response to self- than other-name - was observed in both tasks. In the unconscious condition self-name also evoked greater P3b amplitude, but only in the identification task in which the identity of a name was task-relevant. Our results demonstrate that the P3b component can be in principle modulated by an unconscious stimulus, provided it is salient and task-relevant. Thus, our findings cast doubt on interpreting the P3b component as NCC, while at the same time indicate a close relationship between this component and higher order cognitive processes, also during unconscious perception.

## **Common and distinct neural correlates of peripersonal space and body ownership over the hand, face and trunk**

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Body ownership (BO) is the sense that our body belongs to us, while peripersonal space (PPS) refers to the space around the body. Recent research suggests that BO relies on the visuotactile integration constrained into PPS. In this study, we examined the neural substrates of BO and PPS representation using functional magnetic resonance imaging. Specifically, we investigated these substrates for the hand, the face and the trunk to dissociate between body parts and whole-body representations. First, we investigated PPS by comparing visually looming vs receding objects and found higher activation in the visual cortex for looming stimuli while paracingulate cortex, right sensorimotor cortex and right ventral premotor cortex were found for receding stimuli. Body part-specific activations were only found for face in ventral visual stream. In the BO session, we compared visuotactile asynchronous to synchronous stimuli and asked about the subjective ownership of body part and whole body. We found an activation of left superior parietal lobule for asynchronous vs synchronous stimuli. No body part-specific activations were found at a conventional threshold. In a regression analysis, we found a significant effect in the early visual cortex for face- and hand-ownership in the synchronous condition. Moreover, the regression with whole-body ownership difference between synchronous and asynchronous conditions provided significant activation in bilateral insulae and bilateral ventral premotor cortices. Our data provide evidence in favor of a common role of the visual cortex for body-part specific processing while the premotor cortex may support a more global aspect of BO and PPS.

## **Impact of odors and their perceptual features on sleep**

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Despite gating mechanisms from the thalamus, sensory stimuli can be processed during sleep. Robust recent evidence supports that various types for sensory stimulation may influence sleep features. Yet, although aromatherapy is thought to benefit sleep, studies on the effects of odors on sleep remain scarce, and with inconsistent conclusions. Here, we investigated the impact of odor hedonicity (valence) and intensity on human sleep using polysomnography. Sixteen (N=16) healthy participants (screened for psychiatric, psychological and olfactory disorder) evaluated fourteen complex odors. Out of the fourteen, we selected the two most pleasant, two most unpleasant, and four neutral odors for each participant. We then recorded polysomnography during three nights at the laboratory for each participant: One without odor (control), one with the two good and two neutral odors, and one with the two bad and the two neutral odors. We then tested for the effects of odor valence and intensity on sleep architecture and sleep electrophysiological markers. We found that only odors with higher perceptual intensity had an impact on sleep by reducing the latency to fall asleep and the time spent awake after the onset of sleep. Note that both these sleep parameters are the two main features affected in insomnia. However, and consistent with some previous studies, we found little if no impact of the hedonic value of odors on sleep measures. By improving the selection of chemicals and concentrations used in aromatherapy, we believe that odors could become a powerful ally to treat some forms of insomnia.

## **A Bird's Eye View Lying Down: The Temporo-parietal Junction's General Role in Egocentric Reference Frames**

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The temporo-parietal junction (TPJ) consistently emerges in other-regarding behavior, including in tasks probing affective phenomena such as morality and empathy. Yet the TPJ is also recruited in processes with no affective or social component, such as visuo-spatial processing and mathematical cognition. We present incidental findings from a perceptual decision-making task on a bistable stimulus, the Necker Cube, performed during fMRI acquisition. The Necker cube is a transparent, wire-frame cube that evokes spontaneous switches in perception. Individuals can view the cube from below or from above, though a consistent bias is shown towards seeing the cube from above. We replicate this behavioral bias, finding participants spend more time in the from-above percept. However, in testing for BOLD differences between percept orientations, we find robust responses in bilateral TPJ for the from-above > from-below perceptual state. We speculate that this neural response comes from the sensory incongruence of viewing an object from above while lying supine in the scanner. We further speculate that the TPJ resolves this incongruence by facilitating egocentric projection. Such a function would explain the TPJ's ubiquitous response to other-regarding, visuo-spatial and mathematical cognition, as all these phenomena demand an ability to ambulate through Euclidean space. Our findings suggest the TPJ may not play a specific role in social or moral components of other-regarding behavior such as altruism. Our results indirectly suggest that “pure”, allocentric altruism may not correlate with the TPJ and highlight the need to ensure stimuli are congruent with a supine position in neuroimaging studies.

## **Automatic attention capture by unconsciously perceived self-face**

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Multiple previous studies demonstrated that self-related information, for instance self-name or self-face, is processed preferentially and automatically attracts attention. In the present study we investigated whether an image of participant's self-face can capture attention even when processed without awareness. We tested 29 participants who completed a classic dot-probe task, in which images of a self-face and other-face were presented for 32 ms on both sides of the fixation cross as task-irrelevant distractors. Faces were followed either by masks (subliminal condition) or by a blank screen (supraliminal condition). Next, subjects performed an identification task to evaluate efficiency of the masking procedure. The N2pc ERP component was analysed as an index of covert attention shifts in the dot-probe task. The  $d'$  sensitivity measure indicates that subjects easily identified their own face in the supraliminal task, but performed close to chance level in the subliminal (masked) condition. We found a significant N2pc component in the supraliminal and, crucially, in the subliminal dot-probe task. This indicates that in both conditions subjects covertly shifted attention to their own-face. By showing that the self-face attracts attention without consciousness our study provides an example of dissociation between attention and consciousness. Further, we show that identity of a face, in particular a self-face, can be "identified" without consciousness.

## **Learning to regulate subliminal perception in the healthy human brain**

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Research in healthy people indicate that briefly presented face stimuli in masking paradigms can evoke subliminal activation in specific visual areas, while they are not consciously perceived by the subject (Brooks et al., 2012). In the current project, real-time fMRI neurofeedback (NFB) was used to train 20 healthy volunteers, over the course of 3 sessions, to enhance such subliminal activation in the fusiform face area (FFA). A matched control group (n=19) was subjected to the same training protocol but received a feedback signal based on right inferior parietal sulcus (IPS) activity. While being presented with masked subliminal fearful faces, 11 participants from the FFA-group learned to self-regulate their right FFA evoked neural response (FFA-learners). Similarly, in the IPS group, 9 participants gained voluntary control over their evoked IPS signal (IPS-learners). In line with anticipated practice effects, both the FFA and IPS group improved their ability to detect subliminally presented faces. Critically however, the improvement was strongest for the FFA-learners while for the FFA non-learners this effect was smaller and for the IPS-learners non-existent. Finally, as measured by a subliminal repetition suppression task, only the FFA-learners showed enhanced functional processing of subliminal fearful faces in the right FFA. As such, these results suggest that 1) it is possible to gain control over evoked brain activity in the FFA and 2) that this learned self-regulation may lead to the improved detection as well as functional processing of subliminal faces.

## **Parietal neurons accumulate evidence leading to perceptual awareness**

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In this study, we sought to characterize perceptual consciousness and monitoring through decisional processes. We asked 18 healthy volunteers and one epileptic patient implanted with a microelectrode array in the posterior parietal cortex (PPC) to report weak vibrotactile stimuli and subsequently provide confidence ratings about the correctness of their reports (delayed response task). We found overlapping electrophysiological correlates of detection and confidence resembling an evidence accumulation process at the scalp level, as well as at the single neuron and population level in the PPC. In a second experiment with immediate responses, we verified that these neuronal responses corresponded to a buildup of choice-predicting activity towards a decision. Our behavioral and electrophysiological results were reproduced by a computational model simulating a bounded evidence accumulation process with leakage. The model considered a stimulus as detected if accumulated evidence reached a given bound, and confidence to be proportional to the maximal level of accumulated evidence independently of stimulus detection. Together, these results describe the neural implementation of a simple decision-making mechanism underlying first and second-order conscious reports in the parietal cortex.

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## **Complex naturalistic stimuli maintained in working memory capture attention automatically - an ERP study**

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Recent studies suggest that a stimulus actively maintained in working memory (WM) automatically captures visual attention when subsequently perceived. However, such a WM guidance effect has been so far observed only for stimuli defined by one simple feature (color). Here we investigated whether the guidance effect occurs also for complex and naturalistic stimuli, which are defined by multiple features and relations among them, specifically for faces and houses. The experiment comprised two conditions – a WM condition and a mere exposure condition. After remembering or seeing a stimulus, subjects performed several trials of a dot-probe task, in which pairs of stimuli were presented laterally as distractors (remembered or seen on the one side, control stimulus on the other) and followed by a target dot, to which subjects reacted by pressing a button. We found that subjects' response was faster when the target dot followed a memorized face ( $t(27) = -4.21$ ,  $p < 0.001$ ,  $BF = 230.18$ ) or house ( $W = 60.00$ ,  $p < 0.001$ ,  $BF = 10.62$ ), than when it followed a control stimulus. Further, the N2pc component was evoked by memory-matching faces ( $t(27) = -3.22$ ,  $p < 0.01$ ,  $BF = 23.36$ ) and houses ( $t(27) = -1.69$ ,  $p = 0.05$ ,  $BF = 1.32$ ). Importantly, neither RT, nor N2pc effect were observed in the mere exposure condition. In conclusion, behavioral and electrophysiological data jointly indicate that complex visual stimuli automatically attract attention when maintained in WM. The interaction between WM and attention can be thus further explored in more ecological settings.



## **Auditory aversion and neural entrainment to 40 Hz sounds probe inter-individual anxiety**

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Anxious people often exhibit exaggerated responses to salient or unpleasant sensory events 1. What causes anxiety at the neural level and why some are more apprehensive and responsive to aversive stimuli remains unclear. Here, we aimed to test the hypothesis that anxiety involves over-responsivity of the Salience Network (SN), which plays a central role in aversion and anxiety 2. Building upon recent results showing that 40 Hz sounds probe the responsivity of the SN 3, we hypothesized that subjective aversion and neural responses to these sounds might account for inter-individual anxiety levels. Twenty-five participants rated the aversiveness of click trains between 10 Hz and 250 Hz during EEG recordings. First, we found that aversion ratings substantially vary across frequencies and participants and covary with individual STAI(-trait) anxiety levels (Fig.1A). While most anxious participants rate rough (30-60 Hz) sounds as more unpleasant, least anxious participants rate high-frequency trains (>180 Hz) more negatively. Focusing on EEG responses, we found that whereas anxiety does not affect early auditory ERPs (Fig.1B), the strength of later [200-800ms] sustained auditory steady-state responses (ASSR) to 40 Hz sounds correlates with negative ratings and accounts for individual anxiety levels (Fig.1C). Altogether, these results suggest that emotional and electrophysiological responses to 40 Hz sounds reliably probe the responsivity of the SN and predict individual anxiety. This suggests that aversion to 40 Hz sounds and ensuing brain response constitute viable biomarkers to assess the effect of therapeutic interventions on neural and emotional responsivity in anxiety disorders.

## **Self-attenuation of thoughts**

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Previous studies have shown that self-produced stimuli in auditory, visual and somatosensory domains are attenuated compared to externally generated ones, both at the perceptual and neural level. Currently, there is no evidence on whether an attenuation also occurs for thoughts. In this study, we aim at better understanding how thoughts are processed and more importantly how the brain perceives them as being self-generated while recording brain activity using fMRI. Self-generated thoughts were defined as the number of self-generated words that participants could think of when given the first letter as a cue. In a second condition (externally generated thoughts), participants listened to words and had to recognize words containing a cued letter. To assess the attenuation selective for self-generated thoughts, in both conditions, participants had to estimate the number of self-generated or externally triggered thoughts. Our behavioral results show that participants underestimated the number of self-generated and externally triggered thoughts ( $-0.05 \pm 0.11$ ) and that the underestimation was stronger for self-generated thoughts ( $-0.07 \pm 0.11$ ) than for the externally triggered thoughts ( $-0.04 \pm 0.12$ ;  $F(1,24)=5.85$ ,  $p=0.023$ ). The fMRI results show that the left posterior inferior temporal gyrus was negatively associated with trial-wise fluctuations of the estimation performance only during the condition of self-generated thoughts. Suggesting, that the bigger the underestimation of self-generated thoughts, the more reduced the BOLD signal is in this area. Collectively, our results show for the first time, that self-attenuation also occurs during thinking.

## **Bidirectional dynamic message-passing in a hierarchical active inference model of speech perception**

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Although several proposals exist for how the brain might use internal models to drive perception and behavior, there is no clear understanding of the neuronal representations of the underlying message passing between processing hierarchies. This is particularly true for speech and its characteristic deep temporal structure. To shed light on this issue, we build a model of speech perception based on active (Bayesian) inference (Friston et al., Neural Computation, 2016). It contains a hierarchy of nested discrete states that represents sentences as sequences of words, words as sequences of syllables, and makes contact with the sensory periphery through a continuous model relating discrete syllables to their continuous spectrogram. Within the discrete hierarchy (sentence, word, syllable), each level initiates a complete sequence of state transitions at the level below, while the average of this sequence of states at the lower level informs how the upper level transitions to the next state. Through this model, we hope to understand top-down and bottom-up message passing in central auditory processing stages. The continuous part of the model has been linked to thalamical functions and associated with predictive coding (Friston et al., Network Neuroscience, 2017).

## **Biased representation of naturalistic visual stimuli following visuomotor adaptation in virtual reality**

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Our lifetime experience and past interactions with the world shape the way we act and perceive, but can a brief experience of altered real-life interactions change subsequent brain activity? In the current work, we used immersive virtual-reality (VR) environment to create a lateral displacement between visual and proprioceptive inputs of hand position during a dynamic reaching game. During the game, the virtual hand was shifted rightwards with respect to the real hand, resulting in a recalibration of movements towards the left side of space ('visuomotor adaptation'). Participants (n=15) freely viewed an identical series of visual only naturalistic movies in the MRI before and after the VR-adaptation experience. We found that following VR-adaptation there was higher visual activation in the right parieto-occipital sulcus, corresponding to retinotopic visual area V6, an area that has been associated with peripheral peri-personal space representation (Galletti et al., 1999). Additionally, an auditory area in the right superior temporal gyrus, which was deactivated during movie viewing, became more deactivated following VR-adaptation. This deactivation might reflect cross-modal inhibition, which facilitates attention in one modality in the absence of relevant inputs from other modalities (Laurienti et al., 2002). Together, these findings demonstrate an enhanced visual representation of the left portion of space following right VR-adaptation. This biased representation might be mediated by a leftward bias in spatial attention that accompanies the bias in motor actions during and following adaptation. Thus, a change in visuomotor interactions with the environment might lead to a change in subsequent attention and perception.

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Poster abstracts are preceded by a 'P'

Talk abstracts are preceded by a 'T'

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