



Alpine Brain Imaging Meeting

Champéry, Switzerland, January 9-13, 2022

P R O G R A M



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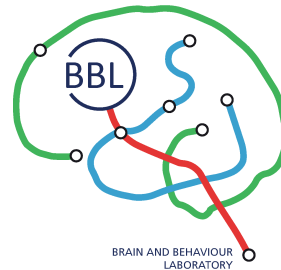


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ABIM cover from Frédéric Grouiller, photo taken at ABIM 2019.

Alpine Brain Imaging Meeting

Champéry 2022

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Locations:

Registration and opening keynote lecture on Sunday will be held at the *Centre Paroissial et Culturel*. The welcome reception on Sunday will be outside *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 *Centre Paroissial et Culturel* (Route des Dents Blanches, 28; see map) on Sunday, the 9th of January from 16:00 to 17:30. 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) and will be followed by an informal **welcome reception** with wine & soup outside the Hotel Suisse, in front of the Church . 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. Three poster sessions will be held on Monday 10th, Tuesday 11th and Wednesday 12th of January in the afternoon (check program). 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 = « ABIM22 », Login = ABIM, Password = 2022).

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.

A **farewell dinner** is planned on Thursday night at the restaurant *Le Gueullhi* (Route de la Fin, 11). The dinner will be free for all registered participants, excluding beverages. Please refer to the staff at the registration desk before Tuesday January 11th for any changes regarding your participation to the dinner. A **prize ceremony** will be held with best poster and best presentation awards.

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.

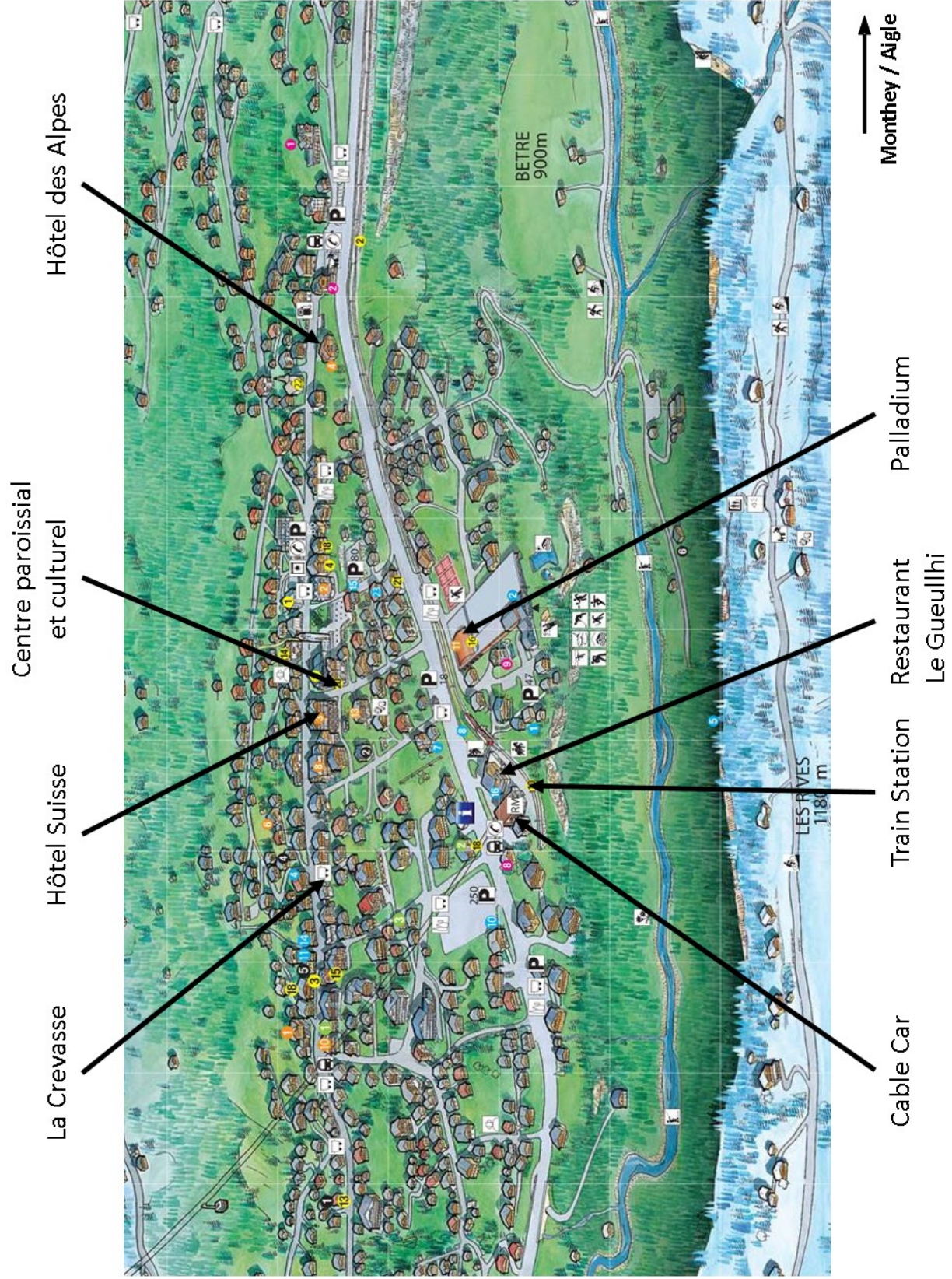
A **swimming pool** and **skating arena** can also be found at the *Palladium*.

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



Alpine Brain Imaging Meeting 2022

PROGRAM OVERVIEW

SUNDAY, January 9th

OPENING LECTURE

16:00-17:30 **Registration** (Centre Paroissial et Culturel)

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

Stanislas DEHAENE | *Collège de France, Paris, France*

- *Symbols, languages and recursion: new data on the singularity of the human brain*

18:30-20:30 **Welcome Reception sponsored by CIBM**

(Hotel Suisse – outdoor in front of the Church)

MONDAY, January 10th

LANGUAGE & DEVELOPMENT

15:30 **Alicja M. OLSZEWSKA** | *Nencki Institute of Experimental Biology, Warsaw, Poland*

- *When Ears Deceive You. Processing of Auditory Incongruence in Musicians - preliminary results*

15:50 **Joanna BECK** | *Nencki Institute of Experimental Biology, Warsaw, Poland*

- *Letter and speech sound association in early blind children and adults*

16:10 **Angela PASQUALOTTO** | *University of Geneva, Geneva, Switzerland*

- *Enhancing reading skills through a video game mixing action mechanics and cognitive training*

16:30 **Ilaria SANI** | *University of Geneva, Geneva, Switzerland*

- *A three-node network for Attention and Object-space perception*

16:50 **Coffee Break**

17:30 **Lionel NACCACHE** | *Institut du Cerveau, Paris, France*

- *Importance, limits and caveat of the use of Disorders of Consciousness to explore consciousness*

18:15 **Poster Blitz Presentations**

18:25-20:00 **Poster Session**

TUESDAY, January 11th

SOCIAL PERCEPTION & COGNITION ACROSS PRIMATE SPECIES

15:30 **Olga DAL MONTE** | *Dept. of Psychology, University of Turin, Italy*

- *Neural Mechanisms of Dynamic Social Interactions*

16:15 **Reidar RIVELAND** | *University of Geneva, Geneva, Switzerland*

- *Talking Nets: Networks Trained to Understand and Communicate Natural Language Instructions*

16:35 **Leonie KOBAN** | *Sorbonne University, Paris, France*

- *An fMRI-based brain marker of individual differences in delay discounting predicts overweight and metabolic markers*

16:55 **Coffee Break**

17:30 **Caspar M. SCHWIEDRZIK** | *European Neuroscience Center, Göttingen, Germany*

- *The face processing system as a test bed for theories on predictive processing*

18:15 **Poster Blitz Presentations**

18:25-20:00 **Poster Session**

WEDNESDAY, January 12th

EMOTIONS

15:30 ➤ **Raffael KALISCH** | *Leibniz Institute for Resilience Research, Mainz, Germany*

- *Replicability in neuroimaging-based emotion research*

16:15 ➤ **Marius Vollberg** | *Harvard University, Boston, USA*

- *The Interplay between Episodic Memory and Empathy*

16:35 ➤ **Lauri NUMMENMAA** | *Turku PET Centre, Turku, Finland*

- *Opioidergic regulation of the human fear response*

16:55 ➤ **Coffee Break**

17:30 ➤ **Christian WAUGH** | *Wake Forest University, Winston-Salem, USA*

- *Positive Appraisal in the Regulation of Stress (PARS): A neuroaffective model*

18:15 ➤ **Poster Blitz Presentations**

18:25-20:00 ➤ **Poster Session**

THURSDAY, January 13th

CONSCIOUSNESS & DECISION MAKING

15:30 ➤ **Valentin WYART** | *Ecole normale supérieure, Paris, France*

- *Controllability shapes human learning and decision-making under uncertainty*

16:15 ➤ **Herberto DHANIS** | *EPFL, Lausanne, Switzerland*

- *Bi-directional control over networks associated with robotically mediated hallucinations through co-activation pattern based real-time fMRI neurofeedback*

16:35 **Lucas Peek** | *University of Geneva, Geneva, Switzerland*

- *Investigating the roles of Fusiform Face Area and Occipital Face Area in Human Face processing: a real-time fMRI neurofeedback study*

16:55 **Coffee Break**

17:30 **Christian MIKUTTA** | *University Hospital of Psychiatry, Bern, Switzerland*

- *Electrocorticographic activation patterns during Electroencephalographic microstates*

17:50 **Olivier RENAUD** | *University of Geneva, Geneva, Switzerland*

- *The Cluster Depth Tests: Toward Point-Wise Strong Control of the Family-Wise Error Rate in Massively Univariate Tests in M/EEG*

18:10 **Andrea SANTORO** | *EPFL, Geneva, Switzerland*

- *Unveiling the higher-order structure of multivariate time series*

18:30 **Thomas BOLTON** | *UNIL, Lausanne, Switzerland*

- *The statistical signature of the passage of time in fMRI time series*

20:30 **Farewell dinner with prize ceremony**

- *Restaurant “Le Gueullhi”*

ABSTRACTS OF ORAL PRESENTATIONS

The themes of the days are:

Sunday: **OPENING LECTURE**

Monday: **LANGUAGE & DEVELOPMENT**

Tuesday: **SOCIAL PERCEPTION & COGNITION ACROSS
PRIMATE SPECIES**

Wednesday: **EMOTIONS**

Thursday: **COUNSCIOUSNESS & DECISION MAKING**

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

A ★ marks presentations from invited speakers.

Sunday

Opening Lecture

O1

Symbols, languages and recursion: new data on the singularity of the human brain

Stanislas Dehaene¹

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Communicative language is often seen as the key factor that explains the cognitive singularity of the human species. Instead, I will propose the hypothesis that humans are characterized by multiple internal “languages of thought”, distributed in various cortical areas, which allow them to understand and compress any concept, whether linguistic, mathematical, musical... Each language is characterized by (1) the discretization of a domain using a small set of symbolic primitives, and (2) their recursive combination into nested structures of unbounded complexity. I will present experiments in three different domains: spatial sequences, binary sound sequences, and geometric shapes. In each case, human perception, memory, and brain activity are determined by minimal description length in the proposed language, where as non-human primate performance is captured by simpler non-symbolic models.

Language and Development

O2

When Ears Deceive You. Processing of Auditory Incongruence in Musicians - preliminary results

Alicja M. Olszewska¹, Dawid Drożdżel¹, Maciej Gaca¹, Agnieszka Kulesza¹, Wojciech Obrębski^{2,3}, Jakub Kowalewski³, Agnieszka Widlarz⁴, Artur Marchewka¹, Aleksandra M. Herman¹

¹Laboratory of Brain Imaging, Nencki Institute of Experimental Biology of the Polish Academy of Sciences, Warsaw, Poland, ²Department of Nuclear and Medical Electronics, Faculty of Electronics and Information Technology, Warsaw University of Technology, Warsaw, Poland, ³Smit-lab, Warsaw, Poland; <http://smit-lab.eu/>, ⁴Chair of Rhythmics and Piano Improvisation, Department of Choir Conducting and Singing, Music Education and Rhythmics, The Chopin University of Music, Warsaw, Poland

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Musicians use auditory feedback, e.g. sound pitch, to monitor their performance for errors and facilitate learning. The aim of this project is to investigate the processing of errors, understood as a mismatch between the expected and perceived auditory feedback, in musicians. For this purpose, we developed a highly ecological, MRI-compatible keyboard instrument. Fifteen musicians (female, 19-26 yo) played various musical scales with their right hand while in an MRI scanner without looking at their hands. In half of the trials, errors were simulated by replacing the auditory feedback of a single key with a sound corresponding to a neighbouring key. The keypresses were recorded, and the performance correctness was compared to a perfect performance using Levenshtein's ratio. Statistical comparison between auditory feedback conditions (altered vs correct) was conducted using one-way repeated-measures analysis of variance. Neuroimaging data were preprocessed and statistically analysed using SPM12 software. In the feedback condition, we directly compared altered and correct auditory feedback trials using one-sample t-tests. A voxel-wise height threshold of $p < 0.001$ (uncorrected) combined with a cluster-level extent threshold of $p < 0.05$ (FWE corrected) was applied. At the behavioural level, the scales were played nearly perfectly for both conditions, with no statistical difference. Neuroimaging data analyses showed increased activation bilaterally in the visual cortex, left supplementary motor cortex, and pars triangularis and pars opercularis. Taken together, despite no differences in behaviour, we observed the activation of structures involved in error monitoring and processing when musicians played with altered auditory feedback.

Language and Development

O3

Letter and speech sound association in early blind children and adults

Joanna Beck¹, Gabriela Dziegiel-Fivet¹, Katarzyna Jednoróg¹

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The first and critical step for reading development is learning letter-speech sound (LS) association. In sighted adults and children LS integration is related to left superior temporal cortex activity (Blau et. al. 2009). Where the LS integration takes place in the blind and how similar this process is to the sighted population is unknown. Pishnamazi et. al. (2016) suggested that blind adults do not integrate audio-tactile syllables due to the mal-development of multisensory mechanisms, but small sample and lack of sighted controls greatly limit these findings. To better understand LS integration, we tested 40 early blind children and adults and compared their brain activity for letters, speech sounds, and congruent and incongruent LS pairs to a matched population of sighted controls. Behaviorally, the blind showed enhanced verbal abilities compared to the sighted and similarly accurate but slower reading. No differences between the groups were found in accuracy or reaction times for bimodal LS stimuli. We will present both within-group comparisons between congruent and incongruent LS pairs (congruency effect) as well as argue that audio-tactile LS integration takes place in blind subjects' brains, though not exactly in the same areas as in the sighted but still in those which are involved in language processing in the sighted. Additionally, the direction of the congruency effect differs between sighted and blind subjects.

Language and Development

O4

Enhancing reading skills through a video game mixing action mechanics and cognitive training

Angela Pasqualotto¹, Daphne Bavelier², Paola Venuti³

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Learning to read is a complex and multifaceted process that relies not only upon language abilities but also upon several executive functions (EFs). The complexity of reading appears particularly clear in the case of developmental dyslexia (DD). In recent years, there has been a growing evidence supporting the presence of EFs deficits in DD, yet few studies have assessed the potential of EFs training in facilitating reading acquisition.

For this reason, we developed a video game-based intervention, called Skies of Manawak (SOM), aimed at improving several aspects of attentional control. A novel feature of our approach is to use hybrid video game that combines mini-games geared to train several facets of EFs through a central action-based video game, leveraging the impact such game mechanics has on attentional control enhancement. The efficacy of SOM has already been tested with typically reading children, and here we present the impact of a twelve hours intervention (5-weeks span) in Italian children with DD (n =55; 8-13 years old). The experimental training group was assigned to SOM (n=30), while the active control group was assigned to Scratch (n=25), a gamified computer programming software. Assessment upon training completion indicated greater improvements not only in several EFs (e.g., visuo-spatial attention) but also in reading fluency and phonological awareness after SOM than after the control training Scratch.

Language and Development

05

A three-node network for Attention and Object-space perception

Ilaria Sani¹, Patrik Vuilleumier¹

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Endogenous attention is the cognitive function that selects the relevant pieces of sensory information to achieve goals and it is known to be controlled by dorsal fronto-parietal brain areas. I will present recent evidence showing that the inferior-temporal cortex also plays a role. By combining a demanding behavioral paradigm with functional neuroimaging and diffusion tractography across primate species, I will show that like fronto-parietal attentional areas, the posterior inferotemporal area (PIT) exhibits significant attentional modulatory activity. More specifically, PIT might be specifically responsible for object-centered attentive perception, while dorsal fronto-parietal areas for ego-centered attentive perception. This area is functionally distinct from surrounding cortical areas, is directly connected to parietal and frontal attentional regions, and preserved across species. These results show that attentional control spans three cortical lobes and overarches large distances through fiber pathways that run orthogonally to the dominant anterior-posterior axes of sensory processing, thus suggesting a different organizing principle for cognitive control that capitalizes on the full functional repertoire of the dorsal and ventral visual streams.

Monday

Language and Development

O6

Importance, limits and caveat of the use of Disorders of Consciousness to explore consciousness

Lionel Naccache¹

¹Institut du cerveau, Paris, France

Tuesday

Social Perception and Cognition across Primate Species

O7

Neural Mechanisms of Dynamic Social Interactions

Olga Dal Monte¹

¹Dept. of Psychology, University of Turin, Italy, ²Department of Psychology, Yale University, New Haven, CT, USA

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Social interactions are characterized by a series of other-regarding decisions and coordinated actions. One critical component of social processing is the computation of prosocial and antisocial decisions. Recent studies have begun to elucidate how neurons from the prefrontal cortex and the amygdala are engaged in social decision-making. We recently reported the first direct evidence of specialized coordination between the medial prefrontal cortex (mPFC) and the basolateral amygdala (BLA) during social decision-making. We found enhanced coordination of neural activity between mPFC and BLA for prosocial decision preference but suppressed coordination for antisocial decision preference. This neuronal coordination recruited specific frequency channels and exhibited a selectively increased directionality of information flow from BLA to mPFC for prosocial decisions.

Our recent work shows that neurons in the prefrontal-amygdala network also encoded spontaneously occurring, face-to-face, social gaze behaviors. Many neurons in the orbitofrontal, dorsomedial prefrontal, and anterior cingulate cortices, in addition to the amygdala, exhibited temporally diverse social discriminability, with a selectivity bias for looking at a conspecific compared to an object. Notably, a large proportion of neurons parametrically tracked the gaze of oneself, other, or their relative gaze positions, providing substrates for social gaze monitoring. Furthermore, some neurons in these brain regions showed distinct neural signals for mutual eye contact, modulated by which agent initiated the gaze interaction.

These findings emphasize the contributions of the prefrontal and amygdala circuits within the broad social interaction networks in regulating complex social behaviors.

Social Perception and Cognition across Primate Species

O8

Cognitive control after-effects in the appraisal of other people's pain

Reidar Riveland¹, Alexandre Pouget¹

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One of humans' most astonishing cognitive feats is the dual ability to interpret linguistic instructions to perform novel tasks in very few practice trials and conversely produce a linguistic description for a task once it has been learned. To explore the neural mechanisms that underpin these remarkable abilities, we trained recurrent neural networks to perform a set of common psychophysical tasks simultaneously with task type information provided by the output of a pre-trained transformer architecture processing natural language instructions. To test the extent to which these models can use language to generalize performance to unseen tasks, we trained models on 14 tasks and tested on 2 held out tasks. We found that our language architecture can immediately generalize to unseen tasks, achieving a performance of 80% correct on tasks for which it received no explicit training compared to 27% performance for a model that encodes tasks with orthogonal rule vectors. Examining the first 2 PCs of sensorimotor activity across tasks revealed a highly structured representation aligned along task defined axis, even for previously unseen tasks. Finally, we can invert the network's language comprehension and train a decoder to produce a linguistic description of how it solved the task. Strikingly, when produced instructions are provided to a second network trained to perform all tasks with instructions, the second network achieves near perfect performance (97% on average). To our knowledge, this is the first neural model demonstrating how the compositional nature of language leads to strong generalization in sensorimotor networks.

Social Perception and Cognition across Primate Species

O9

An fMRI-based brain marker of individual differences in delay discounting predicts overweight and metabolic markers

Leonie Koban^{1, 2}, Sangil Lee³, Daniela S. Schelski⁴, Marie-Christine Simon⁴, Caryn Lerman⁵, Bernd Weber⁴, Joseph W. Kable³, Hilke Plassmann^{1, 2}

¹Paris Brain Institute (ICM), INSERM U 1127, CNRS UMR 7225, Sorbonne University, Paris, France, ²INSEAD, Fontainebleau, France, ³University of Pennsylvania, Philadelphia, USA, ⁴University of Bonn, Bonn, Germany, ⁵University of Southern California, Los Angeles, USA

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Individual differences in delay discounting—how much we discount future compared to immediate rewards—are associated with general life outcomes and related to substance use, psychiatric diseases, and obesity. Here, we use machine-learning on fMRI activity during an intertemporal choice task to develop a brain marker of individual differences in delay discounting. Study 1 (N=110) was used as a training and cross-validation set, resulting in significant prediction accuracy ($r = 0.49$) and suggesting an interplay between brain regions associated with affect, value, and cognitive control. The validity of the brain marker was replicated in an independent data set (Study 2, N=145, $r = 0.45$). Responses of the marker also predicted discounting behavior several weeks later, differed between overweight and lean individuals, and predicted blood markers of glucose metabolism. This pattern is a first step towards a generalizable neuromarker of delay discounting and a potentially transdiagnostic phenotype, which can be used as a brain-based target measure in future studies.

Social Perception and Cognition across Primate Species

O10

The face processing system as a test bed for theories on predictive processing

Caspar M. Schwiedrzik^{1, 2, 3, 4}

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Face processing is arguably one of our most important visual skills and interfaces social perception with social cognition. Accordingly, humans and other primates dedicate large amounts of cortical infrastructure to the visual analysis of faces. A vast body of research has characterized the tuning properties and connectivity of the face processing system, making it one of the best-understood parts of visual cortex. This provides an ideal opportunity to test theories of cortical function that state precise hypotheses about tuning properties and the function of cortical connections. I will present data from electrophysiological recordings and functional magnetic resonance imaging in macaque monkeys as well as intracranial recordings in epilepsy patients that test one family of such models, i.e., predictive processing. I will show that sensory predictions about faces are generated in the face processing system on the basis of environmental statistics, and that single neurons in high-level visual cortex can compute prediction errors. Importantly, the hierarchical structure of visual processing pathways that gives rise to invariant representations of faces allows for abstract predictions not bound to the specific low-level features of the stimuli. This principle extends beyond faces to amodal representations of identities. This equips high-level visual cortex with a machinery for generalization that may add additional resources towards the computation of socially highly relevant information such as a person's identity through an efficient neural code.

Wednesday

Emotions

O11

Replicability in neuroimaging-based emotion research

Raffael Kalisch^{1, 2, 3, 4}

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Neuroimaging is used both for mechanistic investigation into neural processing and for prediction of behavior and psychopathology, that is, as biomarker. Good measurement reliability as well as good replicability of findings are critical requirements for both. Increasingly, neuroimaging is also being employed in longitudinal studies, where repeated functional or structural brain measurements are hoped to shed light on mechanisms of development or adaptation, such as prominently in the fields of stress or trauma research. These dynamic studies pose yet a bigger methodological challenge, because mechanistic conclusions about processes of change require particularly reliable and measurement-invariant metrics. These issues are amplified in neuroimaging-based research on emotional processing and affective disorders, where many paradigms and outcomes are less well controlled and less clearly defined than in other fields of cognitive neuroscience.

I will report on studies from our lab that address the questions of how well fMRI measures from emotion-related tasks replicate in different individuals/cohorts and of how reliably they function at re-test within the same individuals. I will elaborate on differences in replicability/reliability as a function of the employed fMRI metric, of individual participant characteristics, and of test-retest intervals. Examples from stress resilience research will be shown to discuss the relevance and future potential of neuroimaging-based emotion research and to highlight some findings.

Emotions

O12

The Interplay between Episodic Memory and Empathy

Marius Vollberg¹, Brendan Gaesser¹, Patrik Vuilleumier², David Sander², Mina Cikara¹

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Affective empathy, feeling what others feel, is a powerful emotion that binds us to one another. Here we ask whether how we mentally represent the scene in which another suffers informs our emotions. For example, when we learn about someone suffering outside of the here and now, such as a refugee devastated by violence or famine, to what extent does our simulation of the scene around the victim heighten our empathic response? Expanding recent advances in the memory literature, we investigate the link between our ability to imagine events—episodic simulation—and empathy in a series of online and laboratory studies ($N > 1000$). First, incidental manipulations of episodic simulation, unrelated in content and structure to the empathy judgment task, increased overall empathy. This relationship was mediated by participant-generated episodic detail of the victim's surroundings. Second, behavioral and neural measures specific to imagining locations predicted affective empathy for others' misfortunes in those locations above and beyond all other elements (i.e., the person or the event). Our data shows the distinct influence of episodic simulation on empathy above and beyond how much we like or imagine the other person.

Emotions

O13

Opioidergic regulation of the human fear response

Lauri Nummenmaa¹, Kerttu Seppälä¹, Henry Karlsson¹, Jussi Hirvonen¹, Vesa Putkinen¹

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BACKGROUND: Endogenous opioid system is an inhibitory neurotransmitter circuit modulating responses to pain and psychological stressors. Opioid agonists have also anxiolytic effects. Fear and anxiety constitute major psychological stressors for humans, yet the contribution of the opioid system to human fear remains poorly characterized.

METHODS: Here we induced intense unconditioned fear in the subjects by gradually exposing them to a living constrictor snake (*Lampropeltis triangulum*; threat trials) versus an indoor plant (*Dieffenbachia maculate*; safety trials). Haemodynamic responses were recorded from 30 subjects during an fMRI experiment with 30 repetitions of both trial types. 15 subjects also underwent positron emission tomography (PET) with agonist radioligand [¹¹C]carfentanil with high affinity for mu-opioid receptors. Separate sessions were performed with repeated threat and safety exposure, respectively. Subjective fear ratings were measured throughout the experiments. Physiological (pupil dilation and heart rate) responses to snake / plant exposure were recorded in 32 subjects.

RESULTS: Self-reports and pupillometric responses confirmed significant experience of fear and concomitant autonomic activation during the threat trials. fMRI data revealed that proximity with the snake robustly engaged brainstem defense circuits as well as thalamus, dorsal attention network and motor and premotor cortices. PET data confirmed that the haemodynamic responses to threat were coupled with downregulated MOR activity in the cingulate gyrus and thalamus.

CONCLUSIONS: Our results suggest that preparatory response during acute fear episodes involves a strong motor component in addition to the brainstem responses. These haemodynamic changes are coupled with deactivation of the inhibitory opioidergic circuit, highlighting the role of MORs in safety signaling.

Emotions

O14

Positive Appraisal in the Regulation of Stress (PARS): A neuroaffective model

Christian Waugh¹

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Experiencing and cultivating positive emotions in the midst of stress is a powerful stress regulation strategy. We propose a novel neuroaffective model of how people use positive emotions to regulate their stress. In this model, the ventromedial prefrontal cortex (vmPFC) and ventral striatum (VS) generate positive appraisals of the environment and of the self. During stress, these regions generate the initial positive appraisals of some stressor elements, and when people initially appraise a stressor element as negative, these regions coordinate with the cognitive reappraisal system to change the meaning of that negative element to be more positive. This vmPFC/VS positive appraisal mechanism is also a critical ingredient in other stress regulation processes, including positive feelings, motivated safety-seeking behavior, physiological soothing and social support. This model contributes to the stress/emotion regulation and neuroscience literatures by outlining multiple psychological mechanisms through which positive appraisal, via the vmPFC/VS, influences people's responses to stress.

Thursday

Consciousness and Decision Making

O15

Controllability shapes human learning and decision-making under uncertainty

Valentin Wyart¹

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Making accurate decisions requires identifying the cause of sensory observations, but also anticipating the consequences of possible actions. Although both cognitive processes can be formalized as hidden-state inference, they are studied in the lab using different experimental frameworks, which makes their comparison difficult. A constitutive, yet rarely considered difference between these two forms of inference lies in the degree of control over information sampling conferred to the decision-maker. In this talk, I will present a series of new findings obtained in my group using an experimental framework where inference with and without control can be compared in otherwise tightly matched conditions. First, I will show that humans perceive the same environment as more stable when inferring its hidden state by interaction with uncertain outcomes (with control) than by observation of equally uncertain cues (without control). Magnetoencephalographic (MEG) activity reflects this cognitive effect in the consistency between sampled information and the inferred hidden state, a neural signal originating from the temporal lobe. I will then compare response switches made with and without control to dissociate information seeking from confounding factors associated with exploration-exploitation dilemmas. Last, I will explain why controllability may be particularly relevant for understanding obsessive-compulsive disorder (OCD), a psychiatric condition often described as a general ‘disease of uncertainty’. Indeed, severe OCD patients show deficits of inference only in the condition with control, where uncertainty concerns the outcomes of their actions. Taken together, these findings indicate that controllability constitutes an important factor for understanding human learning and decision-making under uncertainty.

Consciousness and Decision Making

O16

Bi-directional control over networks associated with robotically mediated hallucinations through co-activation pattern based real-time fMRI neurofeedback

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Presence hallucination (PH), the convincing sensation of having someone close by when no one is there, is reported by healthy and neuro-psychiatric populations. PH is also amongst the earliest, most frequent hallucinations in Parkinson's Disease, and is putatively associated with poorer clinical outcomes. Recently, a prominent study induced PH in healthy individuals through robotically mediated sensorimotor conflicts during fMRI acquisition, and a follow-up study using Co-Activation Pattern (CAP) analysis, identified a fronto-parietal network (PH-network) which becomes dominant in healthy individuals sensitive to PH induction.

Here we used real-time fMRI neurofeedback to test whether 20 healthy individuals could achieve volitional control of this PH-network. During a 5-days experimental paradigm, participants completed a first day to assess their baseline sensitivity to PH-induction, followed by three days of CAP-based neurofeedback training paired with sensorimotor robotic manipulation, where higher feedback was tied to the occurrence of the PH-network. Change in PH-sensitivity due to the neurofeedback training was assessed on a fifth day. Successful participants shifted the transition probabilities across different CAPs to significantly favour either the PH-network or networks that included major components of the PH-network. Successful participants also actively avoided the occurrence of the PH-network during control periods. Furthermore, sustained effects on day 5, were only present for participants sensitive to PH-induction, suggesting that only those retained a change in brain connectivity.

In sum, healthy individuals are capable of bi-directional control of a network related to PH induction, opening the door for investigating a potential hallucination therapy for Parkinson patients afflicted with hallucinations.

Consciousness and Decision Making

O17

Investigating the roles of Fusiform Face Area and Occipital Face Area in Human Face processing: a real-time fMRI neurofeedback study

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According to the traditional hierarchical account of human face processing detection of faces is mediated by the occipital face area (OFA), a region believed to code for face feature extraction (eyes, nose, mouth). Subsequent face identity judgments are then facilitated by the fusiform face area (FFA) where the extracted features are integrated into a global face representation. In contrast, non-hierarchical accounts argue that face information is first coarsely expressed in the FFA (detection) after which information related to face features is provided by OFA through reentrant connections (recognition). Using real-time fMRI neurofeedback (NFB) we tested these opposing claims by training 22 healthy volunteers (experimental group), during two separate sessions to selectively enhance FFA and OFA activity, while they were engaged in a face detection/recognition task. Our results show that participants successfully enhanced OFA activity when compared to their own baseline as well as when compared to the OFA modulation of a yoked control group (N=20). Furthermore, while FFA activity of the experimental group did not surpass baseline, it did exceed the FFA activity of the control group. Lastly, preliminary behavioral results tentatively support the non-hierarchical view: enhanced FFA (but not OFA) activity predicted improved face detection and recognition. However, further analyses need to be conducted to more confidently confirm these initial findings.

Consciousness and Decision Making

O18

Electrocorticographic activation patterns during Electroencephalographic microstates

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Introduction: Electroencephalography (EEG) microstates are successive short time periods of stable scalp field potentials which represent spontaneous activation of brain resting-state networks. In theory, these global EEG microstates mediate more local patterns of activity. In the present study, we explored this assumption by correlating the observed scalp microstates with spectrally transformed electrocorticography (ECoG) and stereotactic electroencephalography (SEEG) recordings.

Methods: We included resting state data (5 min) of two participants with simultaneous non-invasive scalp EEG and ECoG recordings. Data were recorded during presurgical evaluation of pharmacoresistant epilepsies by means of subdural electrodes. SEEG / ECoG electrodes in both participants covered left and right Hippocampus and Amygdala as well as left and right temporal regions. After standard preprocessing, we fitted previously identified microstate template maps (Custo et al. 2017) to the scalp EEG data. By using covariance mapping, we identified the activation of ECoG local field potentials in different frequency bands (theta, alpha, beta, high gamma) during the seven microstates, which last on average for 58 msec.

Results: We found significant covariance maps in all four frequency bands ($p = .001$, permutation test). Covariance patterns of the ECoG electrodes during the different microstates were similar in the two observed participants.

Discussion: We demonstrate distinct activation patterns of frequency domain ECoG local field potentials during previously identified EEG microstates.

Consciousness and Decision Making

O19

The Cluster Depth Tests: Toward Point-Wise Strong Control of the Family-Wise Error Rate in Massively Univariate Tests in M/EEG

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The cluster mass test has been widely used for massively univariate tests in M/EEG and fMRI. It is a powerful method for detecting effects while controlling weakly the family-wise error rate (FWER), although its correct interpretation can only be performed at the cluster level without any point-wise conclusion. It implies that the discoveries of a cluster mass test cannot be precisely localized in time or in space. We propose a new multiple comparison procedure, the cluster depth tests, that both controls strongly the FWER while allowing an interpretation at the time point level. A permutation scheme computes the joint null distribution of the cluster depths and a multiple comparison procedure (step-wise min-p) corrects for the number of tests. The simulation study shows that the cluster depth tests achieve large power and guarantee the FWER even in the presence of physiologically plausible effects. By having an interpretation at the time point/voxel level, the cluster depth tests make it possible to take full advantage of the high temporal resolution of EEG recording to precisely time the appearance of an effect. <https://arxiv.org/abs/2105.07514>

Consciousness and Decision Making

O20

Unveiling the higher-order structure of multivariate time series

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Time series analysis and signal processing have proven to be powerful methods to characterize several phenomena in biology, neuroscience, economics, and to understand some of their underlying dynamical features. Despite several methods currently exists for the analysis of multivariate time series, most of them do not investigate whether the signals stem from either independent, joint, or group interactions. A clear example of this issue is provided by the conventional “functional connectivity” between two brain regions: a pairwise connection is drawn irrespectively of whether the activities of the two regions peaked as a pair, or as part of a larger group of functionally coherent regions.

In this work, we propose a new framework to investigate the higher-order dependencies within a multivariate time series. We distinguish instantaneous co-fluctuation patterns at different group levels (pairs, triplets, etc), and then characterise the additional coherence of higher-order co-fluctuation patterns using topological data analysis tools. We test our framework on synthetic signals generated by coupled chaotic maps, demonstrating that it robustly differentiates various spatiotemporal regimes, including chaotic dynamical phases and various types of synchronization. By analysing fMRI signals, we find that, during rest, the human brain mainly oscillates between chaotic and few partially intermittent states, with higher-order structures reflecting Default Mode Network and somatomotor regions, respectively.

Consciousness and Decision Making

O21

The statistical signature of the passage of time in fMRI time series

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Classical measures of brain activity computed from neuroimaging time series are insensitive to the asymmetry of the passage of time. The statistical signature of this asymmetry, called the ‘arrow of time’ (AOT), is in general hard to detect. Here we use a recent heuristic to assess AOT strength in fMRI time series from 100 unrelated Human Connectome Project subjects. First, we find that the average AOT strength is different when the subjects are at rest vs. when they are performing a task. Second, we compare the spatial distribution of the AOT strength in different tasks to the corresponding activation maps and find that the AOT provides complementary insights into how brain regions are recruited when engaging into a task. Finally, we compare the classical sliding window correlation approach with a ‘sliding window AOT’ and show that the AOT is more sensitive to variations of subjects’ cognitive status. Overall we show that the AOT, which captures statistical information to which classical metrics of brain function are blind, unveils new brain functional mechanisms relevant to the cognitive status. Our results pave the way to defining a new generation of statistical metrics for neuroimaging time series.

POSTER ABSTRACTS

Ordered according to these categories:

Language & Music (Monday)

Methods (Monday)

Clinical Neuroscience (Tuesday)

Learning & Memory (Tuesday)

Emotion & Motivation (Wednesday)

Perception (Wednesday)

Language & Music

M1

Learning to control a brain-computer interface to decode internally spoken syllables

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Real-time decoding of covert speech production from Electroencephalography (EEG) could provide non-invasive means to an end for people with compromised speech, such as in aphasia. But neural signals related to covert speech production are often weak and subject to intra-individual practicability. In the current study, we designed a Brain-Computer Interface (BCI) experiment with real-time feedback using a 64-channel EEG system to record data from 10 healthy participants. The task involved covert speech production of two syllables with different articulatory and phonetic features. We used the Random Forest classifier to ‘train’ (offline) and then to ‘test’ (online) the data with real-time feedback. To know how individuals learned to control the BCI, the participants were trained for 5 consecutive days. Results show an increase in BCI control from training day-1 to -4, followed by a decrease on day-5. This was accompanied by a power increase on day-4 compared to day-1 in left temporal and fronto-temporal electrodes in theta, beta, and high-gamma bands. One electrode (T7) showed significant power-performance correlation across time (consecutive days) and frequency bands. Additional investigation (at T7) shows significant Event-Related Desynchronization in the theta, beta, and low-gamma bands and Event-Related Synchronization in the high-gamma band, all at higher latencies. Overall, individuals could learn to control a speech-BCI although inter-individual variabilities and motivational factors may affect BCI performance. Further, neurophysiological findings implicate that several electrodes and neural oscillations around the ‘eloquent’ cortex were involved during the task. These subsets of features could be used to build efficient future speech-BCI systems.

Language & Music

M2

The role of the left ventral occipitotemporal cortex in speech processing - the influence of visual deprivation.

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The role of the left ventral occipitotemporal cortex (vOT) in reading is well established in both sighted print and blind Braille readers. The left vOTs' activations during speech processing have also been observed in both populations but remain only partially understood. The current study aimed at testing the involvement of the left vOT in phonological processing of spoken language in the blind and in the sighted by means of whole-brain and region-of-interest (including functionally identified within each subject individually) fMRI analyses. Second aim of the study was to examine the relationship between the left vOT activation during speech processing and reading skills. All applied analytical methods confirmed greater involvement of the left vOT in the blind than in the sighted subjects during both phonological and control spoken language tasks. The correlation between the reading level and the left vOT activity was also significant only in the blind group in both tasks. Our results indicate a changed development of the left vOT sensitivity to spoken language, resulting from the visual deprivation. Unlike in the sighted, the left vOT could be involved in speech processing in the blind well before the Braille reading acquisition and this involvement would provide the basis for the Braille sensitivity.

Language & Music

M3

Music or singing voice? Newborns' early discrimination of instruments and voices: a dynamic effective connectivity study

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Newborn infants show early specialization in the treatment of human voices, but little is known about whether this specialization is such only for speaking or even for singing voices. 45 newborns were scanned using functional magnetic resonance imaging while listening to a melody (without words) sang by a female voice (voice condition) or played by a musical instrument, a flute (instrument condition). To explore the dynamic task-based effective connectivity, we employed psychophysiological interaction of co-activation patterns (PPI-CAPs) analysis with auditory cortices as seed region to investigate moment-to-moment changes in task-driven modulation of brain activity during an fMRI task involving both instrument and voice conditions. Our findings revealed unique, condition-specific, dynamically occurring patterns of co-activation (PPI-CAPs). More specifically, based on the PPI effects, we found that the auditory cortex during the voice condition co-activates with cortical somatomotor, frontoparietal and precuneus/angular gyrus regions, while the instrument condition the auditory cortex co-activates with the visual areas and the limbic system, namely the orbito-frontal-cortex and temporal pole. In line with adult studies, the singing voice condition, activating the somatomotor network, evokes body, proprioceptive, and motor aspects of the auditory perception, other than the attentional and cognitive ones, while the musical instrument activates more areas dedicated to emotional and visual stimuli processing. The dynamic aspects of the melody seem thus activating a body experience when presented by the voice and a visual one when played by a musical instrument. This study highlights the relevance of dynamic approaches to study brain function in newborn populations.

M4

Rhythmic modulation of predictions in the low-beta range improves syllable parsing and identification in connected speech

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Speech perception is a hierarchically organized process spanning several cortical areas and using different frequency scales to transfer information up and down the hierarchy. While theta and low-gamma scales are involved in bottom-up packaging of syllabic and phonemic information in the speech signal, the beta rhythm is more loosely associated with top-down processes, without being assigned any specific computational function. Here we assessed the possibility that beta oscillations control the precision of states in the hierarchical inference process. We developed a predictive coding model (Precoss- β) that incrementally recognizes syllables in natural sentences as the speech waveform unfolds in time. In the model, precisions are rhythmically modulated in time, thereby periodically changing whether the inference process is dominantly driven by bottom-up or by top-down information. The model performance improves as the frequency increases up to an inflexion point in the low-beta rhythm (around 20Hz). Moreover, optimal performance arises when predictions pertaining to timing vs identity of syllables oscillate in opposite directions. These results suggest that online syllable identification in natural sentences benefits from the rhythmic enhancement of predictions in the low-beta range, in a way that alternates the updates of what and when streams.

The channel capacity of multilevel linguistic features constrains speech comprehension

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Humans are expert at processing speech but how this feat is accomplished remains a major question in cognitive neuroscience. Capitalizing on the concept of channel capacity, we developed a unified measurement framework to investigate the respective influence of seven acoustic and linguistic features on speech comprehension, encompassing acoustic, sub-lexical, lexical and supra-lexical levels of description. We show that comprehension is independently impacted by all these features, but at varying degrees and with a clear dominance of the syllabic rate. Comparing comprehension of French words and sentences further reveals that when supra-lexical contextual information is present, the impact of all other features is dramatically reduced. Finally, we estimated the channel capacity associated with each linguistic feature and compared them with their generic distribution in natural speech. Our data point towards supra-lexical contextual information as the feature limiting the flow of natural speech. Overall, this study reveals how multilevel linguistic features constrain speech comprehension.

Language & Music

M6

Train the brain with music: brain structural and behavioral plasticity in healthy elderly after 6 months of 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. Musical practice might counteract age-related cognitive decline, but experimental evidence remains sparse. This study combines protocolled music practice in elderly with neuroimaging and psychometric testing, moreover, comparing two types of musical education.

Our two-site Hannover-Geneva longitudinal randomized intervention study in altogether 150 elderly offered either piano (intervention group) or music sensitization education (active control group). Over 12 months participants received weekly training (60 minutes) and exercised at home for ~30 minutes daily. Measurements took place 0, 6, 12 months & post-training (18 months) on cognitive/perceptual-motor abilities (15 behavioral tests) and brain magnetic resonance imaging (MRI) (James et al. 2021).

We will present here results of the intervention in a subgroup of 132 participants that went through MRI after 6 months of musical training. We will present Grey Matter (GM) volume changes between baseline and 6 months (longitudinal voxel-based morphometry pipeline of SPM12 CAT12), showing a widely distributed pattern of GM volume increase in both groups. Then we will show differences between groups in favor of the piano group in auditory/motor regions. We will relate those results to training intensity and behavioral transfer effects. Finally, we will present GM volume atrophy results.

Overall, those results evidence that real-life interventions such as musical training are associated with plasticity in the elderly brain. Such interventions might have the potential to slow age-related cognitive decline although they cannot fully counteract brain physiological decline.

M7

Antagonist effects of auditory cortex tACS on phonemic and prosody processing

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Proficient reading requires to combine the ability to decode the words' phonological structure, and the ability to read with appropriate intonation. While the former develops through grapheme-phoneme mapping, the latter further depends on prosody processing. These two functions however are processed in opposite hemispheric regions, the left temporo-occipital region and the right temporal lobe (Lopes et al., 2015; Miller and Schwanenflugel, 2008; Paige et al., 2017), raising the issue of inter-hemispheric cooperation in typical and atypical reading (dyslexia). In this study, we used focal transcranial alternating current stimulation (tACS) at 30 Hz over the left auditory cortical region to selectively boost phonological processing in 30 adults with and without dyslexia (Marchesotti et al., 2020). We related their reading scores (prosody) before and after tACS to two key neurophysiological variables: the lateralization of 30 Hz activity before tACS (initial lateralization of phonological processing) and the gain in 30 Hz activity following tACS. We found that poor left 30 Hz lateralization was associated both with better initial reading prosody, and with a stronger 30 Hz power gain in left superior temporal gyrus (STG) after tACS which altered prosody processing. This observation was independent of the subjects' dyslexia status. These results indicate that while relateralizing and improving phonological processing, 30 Hz tACS has a negative impact on reading prosody confirming a competition between both processes in reading acquisition.

Language & Music

M8

Brain dynamics of affective experience engendered by tension, in songs with lyrics

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Songs intimately combine two of our species' most distinctive faculties: music and language (M&L). The temporal unfolding of M&L features, such as dissonant chords and evocative words, engenders a fluctuating pattern of tension-relaxation from which aesthetic and emotional experience emerge. Predictive expectations related to such patterns constitute a fundamental brain mechanism underlying emotional responses to song, such as fulfilment and surprise. But how tension gets integrated as affect emerging across M&L is not yet understood.

This poster will present the precursor to a Marie Skłodowska-Curie Action aiming to investigate the cognitive and neural dynamics of tension-induced affect in songs. Through decoding and information-theoretic approaches, the project will link recent computational models of music and of language to ground-truth behavioural and brain activity data (pupillometry, magnetoencephalography). This allows examining any non-linear M&L interaction effects that would support a hypothesis of neurocognitive superadditivity for joint M&L processing. Exploiting the art-song tradition of maximally-affective poems set to music, naturalistic listening conditions will be established, reflecting the time-frame typically required for affect build-up. Although using Western music, the strive is to ultimately uncover culturally-invariant (universal) mechanisms.

The project's results are expected to have broad relevance for our understanding of the human aesthetic experience, a corner-stone of the science-humanities interface. The poster will present the theoretical and methodological premise of the project, and early behavioural pilot data.

Meaning extraction based on hierarchical prediction during speech processing

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Understanding speech is essential for appropriate behaviour. Mapping fleeting, ambiguous soundwaves to meaning is nontrivial and existing models of speech processing focus on either sound-to-word recognition, or abstract linguistic representations.

Here we develop a model that works all the way from continuous acoustic signals to discrete, abstract representations. It extracts multiple levels of information by inverting a hierarchical generative model that represents the listener's internal knowledge of linguistic rules and contextual backgrounds. Top-down predictions and bottom-up updates alternate in a nested temporal hierarchy. Importantly, the meaning of an utterance is separated into two hierarchically related levels: a linguistic level where a formal relationship between semantic and syntax allows the model to incrementally assign values to semantic roles, and a “world level” where the non-linguistic context of the current conversation is inferred from semantic values.

We show that the model can disambiguate multiple meanings of the same word by integrating contextual knowledge, and commits reasonable mistakes when sensory precisions are degraded. We also find that hierarchical predictions reduce the effort of maintaining and updating model estimates, especially when peripheral processing is impaired.

This proof-of-concept model establishes a computational framework in which message-passing organized in a deep temporal hierarchy enables the utilization of structured knowledge in understanding ongoing speech. We show that such a model can be exploited to disentangle functional roles of the language network through information-theoretic measures, which quantify both the uncertainty about representations and the updating process upon new evidence integration at each hierarchical level.

Language & Music

M10

Motor contributions to predictive timing during music listening

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When does motor dynamics contribute to auditory perception and what computations underlie this phenomenon? To test the hypothesis that motor engagement depends on the predictive timing of auditory streams, we built melodies of varying degrees of syncope. We observed a quadratic relationship between syncope and motor involvement, characterized by the urge to move during passive listening (groove). Magnetoencephalography data show that auditory regions track the rhythm of the melodies. Intrinsic neural dynamics instead encode the groove in motor beta dynamics and at 1.4 Hz -the perceptual rhythm of auditory temporal attention- in the left auditory dorsal pathway. Critically, the left parietal cortex subtends the coupling between these 1.4 Hz and beta dynamics, the latter being then relayed via the SMA up to the motor cortex. These results are captured by a computational model of coupled oscillators, suggesting that auditory temporal attention involves motor processes when auditory streams are temporally complex but predictable.

Methods

M11

Brain structure-function coupling provides signatures for task decoding and individual fingerprinting

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The relation between brain functional activity and the underlying wiring structure is complex and varies depending on the specific brain region. Recently, we used graph signal processing (GSP) to introduce the structural decoupling index, a novel metric quantifying structure-function coupling in each brain region. This showed a to vary along a meaningful spatial gradient spanning from unimodal regions, where function is tightly coupled to structure, to transmodal ones, where function is more liberal. Here, we investigate the potential of structure-function coupling to characterize different individuals (fingerprinting) and tasks (task decoding). To this aim, we analyzed functional and diffusion magnetic resonance images of 100 unrelated healthy subjects from the human connectome project (HCP), during resting-state and seven different tasks. Structure-function coupling was quantified with new GSP-based metrics, including structural decoupling index, and its fingerprinting and decoding properties were assessed with support vector machine classification. Results showed high classification accuracies for both decoding and fingerprinting, suggesting structure-function coupling as a reliable brain signature uniquely characterizing both individuals and tasks. Further, the portion of functional activity more decoupled from structure showed to contain key information for fingerprinting, providing insights on clarifying the role of low and high spatial frequencies of the structural connectome. A network mainly involving cortico-subcortical connections showed the strongest correlation between structure-function coupling and cognitive traits, assessed with partial least square analysis, corroborating its relevance for fingerprinting. These results show that brain structure-function coupling provides a new class of signatures of cognition and individual brain organization at rest and during tasks.

Methods

M12

A method to induce low and high flow states while keeping participants on task.

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When the challenge of a task meets the skills of the person doing it, a specific mental state, called flow, can emerge. While the psychological aspects of flow have been well-defined, the neural and physiological correlates leading to its emergence have yet to be unraveled. Currently, experimental investigations of these correlates usually contrast conditions of different challenge levels, with the risk of inducing boredom or frustration in some conditions, both known to lead to disengagement, or off-task behavior. Thus, it remains unclear whether previously observed differences ascribed to flow may rather reflect differences in how much participants stayed on-task.

To remedy this, we present a method to induce states of low and high flow while controlling that participants remain on task in both conditions. Using an action video game, we contrasted a condition where the challenge was matched to the participants' skills to one where the game play challenge was higher than their skills, yet remaining within a playable range. Participants reported significantly different levels of flow state between our two conditions, along with similarly trying their best - and thus remaining on task - in both conditions. Using this paradigm, we also investigated potential physiological correlates of flow. While our data confirmed the known difference between an off-task condition versus our low and high flow conditions, they failed to clearly distinguish between the latter two. This raises concerns about previous physiological characterizations of flow against conditions that did not control for on-task behavior. In sum, the present method provides a methodological advance for manipulating flow, unconfounded from on-task/off-task issues.

Methods

M14

Discovering low-dimensional interpretable dynamics from high-dimensional neuronal activity

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Recent improvements in brain recording techniques have provided tools to record activity from hundreds to thousands of neurons simultaneously. Modeling and interpreting the resulting spike train data is a challenging task that is central to the quest of understanding brain functions. For this task, data-driven models such as point-process generalized linear models (PPGLMs) have been developed to fit and predict neuronal activity. Continuous approximations and basis projections of PPGLMs have previously been introduced as an efficient dimensionality reduction method. Yet, the question of interpreting those equations with regards to functional behavior remains difficult. On the other hand, frameworks such as structured flows on manifolds (SFM) propose a compelling behavior using interpretable dynamical systems but remain detached from actual recordings. To overcome this gap between models, we analytically performed separation between two time scales of the continuous approximation of the PPGLM equations. In the first fast time-scale, high-dimensional dynamics collapse into a low-dimensional manifold, effectively constraining the set of possible behaviors. In the second slow time-scale, trajectories are traced out on the manifold to represent a particular behavior. We demonstrated the functional relevance of this decomposition in simulations of neuronal networks and derived the resulting constraints on the network connectivity matrices. These simulations provide a testbed for the proposed framework, which will be next applied to human microelectrode array recordings during speech processing task, and opens new avenues for the analyses of neural data.

Methods

M15

Resting state fMRI hyperalignment reveals a generalizable fine scale structure of evoked cortical response to noxious stimuli

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Cortical feature representations include mesoscale information that is topographically heterogeneous across individuals. This has limited their characterization to individual brain structures and individual subjects. Resting state hyperalignment provides an indirect but scalable and generalizable alternative that models topographic differences as scaled high dimensional rotations of a common population code manifold. We applied estimated rotations to noxious heat and pressure stimulation of the fingers (N=104 subjects), stimuli that are likely distinguished at the mesoscale. We found hyperalignment reduced interindividual differences in evoked responses and improved local nociceptive modality discrimination throughout the cortex.

Hyperalignment produced significant improvements in searchlight-based between-subject correlations (BSCs) of evoked responses for 88% of the cortex and decreases in BSCs for 0.06% of cortex relative to non-hyperaligned data (permutation test, FDR $p < 0.05$). The largest improvements were in the insula and premotor areas, including putative primary nociceptive areas like SII. We performed a searchlight sweep of each hemisphere with linear support vector machines to test out-of-subject discrimination of noxious modality. Without hyperalignment, 31.9% of the cortex discriminated modality (>55% accuracy, FDR $p < 0.05$, max 71%, contralateral PFM) vs. 73.2% of the cortex with hyperalignment (max 75%, contralateral SII).

We show connectivity hyperalignment captures a common model of cortical nociceptive representation. This model reveals that different modalities of noxious stimuli have divergent effects on cortical activity that are fine scaled but widespread, distributed outside of classic thermosensory areas, and translate across individuals. This demonstrates the viability of hyperalignment for characterizing a generalizable fine structure of cortical nociceptive processing.

Methods

M16

Mapping of structure-function age-related connectivity changes on cognition using multimodal MRI

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The relationship between age-related changes in brain structural connectivity (SC) and functional connectivity (FC) with cognition is not well understood. To this end, we used a longitudinal, within-subject, multimodal approach aiming to combine brain data from diffusion-weighted MRI (DW-MRI), and functional MRI (fMRI) with behavioral evaluation, to better understand how changes in FC and SC correlate with changes in cognition in a sample of older adults.

FC and SC measures were derived from the multimodal scans acquired at two time points for 28 older adults. Change in FC and SC was correlated with 13 behavioral measures of cognitive function using Partial Least Squares Correlation (PLSC). Two of the measures indicate age-related change in cognition and the rest indicate baseline cognitive performance.

FC and SC – cognition correlations were expressed across several cognitive measures, and numerous structural and functional cortical connections, mainly cingulo-opercular, dorsolateral prefrontal, somatosensory and motor, and temporo-parieto-occipital, contributed both positively and negatively to the brain-behavior relationship. Whole-brain FC and SC captured distinct and independent connections related to the cognitive measures.

Overall, we examined age-related function-structure associations of the brain in a comprehensive and integrated manner, using a multimodal approach. We pointed out the behavioral relevance of age-related changes in FC and SC. Taken together, our results highlight that the heterogeneity in distributed FC and SC connectivity patterns provide unique information about the variable nature of healthy cognitive aging.

Methods

M17

Dynamics of Functional Network Organization Through Graph Mixture Learning

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Understanding the organizational principles of human brain activity at the systems level remains a major challenge in network neuroscience. Here, we introduce a fully data-driven approach based on graph learning to extract meaningful repeating network patterns from regionally-averaged time-courses. We use the Graph Laplacian Mixture Model (GLMM), a generative model that treats functional data as a collection of signals expressed on multiple underlying graphs, learned without resorting to structural information. Our approach overcomes the problem of dealing with subjective parameters (e.g., sliding window lengths) and utilizes the entire signal as input. The output generated is characterized by K states, each characterized by a graph and a probability that captures its dynamic.

To validate the proposed technique, we first apply it to task fMRI with a known experimental paradigm. The probability of each graph to occur at each time-point is found to be consistent with the task timing, while the spatial patterns associated to each epoch of the task are in line with previously established activation patterns using classical regression analysis. We further on apply the technique to resting state data, which leads to extracted graphs that correspond to well-known brain functional activation patterns.

The GLMM allows to learn graphs entirely from the functional activity that, in practice, turn out to reveal high similarity to the structural connectome.

The Default Mode Network is consistently captured by the algorithm in the different tasks and resting state data. Therefore, we compare the states corresponding to this network within themselves and with structure.

Methods

M18

Exploring MEG brain fingerprints: Evaluation, pitfalls, and interpretations

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Individual characterization of subjects based on their functional connectome (FC), termed “FC fingerprinting”, has become a highly sought-after goal in contemporary neuroscience research. Recent functional magnetic resonance imaging (fMRI) studies have demonstrated unique characterization and accurate identification of individuals as an accomplished task. However, FC fingerprinting in magnetoencephalography (MEG) data is still widely unexplored. Here, we study resting-state MEG data from the Human Connectome Project to assess the MEG FC fingerprinting and its relationship with several factors including amplitude- and phase-coupling functional connectivity measures, spatial leakage correction, frequency bands, imaging modalities and behavioral significance. Our results suggest that fingerprinting performance is strongly influenced by the choice of the functional connectivity measure, frequency band, identification scoring method, and spatial leakage correction. We report higher MEG fingerprinting performances in phase-coupling methods, central frequency bands (alpha and beta), and in the visual, frontoparietal, dorsal-attention, and default-mode networks. Furthermore, cross-modality comparisons reveal a certain degree of spatial concordance in fingerprinting patterns between the MEG and fMRI data, especially in the visual system. Finally, the multivariate correlation analyses show that MEG connectomes have strong behavioral significance, which however depends on the considered connectivity measure and temporal scale. This comprehensive, albeit preliminary investigation of MEG connectome test-retest identifiability offers a first characterization of MEG fingerprinting in relation to different methodological and electrophysiological factors and contributes to the understanding of fingerprinting cross-modal relationships. We hope that this first investigation will contribute to setting the grounds for MEG connectome identification.

Methods

M19

Do saline-solution based EEG systems constitute a valuable alternative to conventional gel-based EEG system? A pilot study

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High-density electroencephalography (EEG) acquisitions are of crucial importance for source reconstruction and connectivity analyses in both research and clinical fields. Nonetheless, the application of such high-density gel-based solutions is time-consuming and relies on the involvement of trained personal. To facilitate the rapid acquisition of high-density data, several commercially available sensor solutions have been proposed (e.g. dry electrode solutions and saline solution-based EEG systems). Nonetheless, whether such alternative sensor types produce data of comparable signal quality and reliability is often debated. Here, we propose a direct comparison between gel-based, conventional silver/silver chloride (Ag/AgCl) electrode setups and potassium chloride (KCl)-solution based silver (Ag) electrode setups.

To this end, data were acquired from a small set of subjects within the same experimental conditions for both EEG sensor types. Specifically, subjects performed two separate tasks: a visual discrimination task and an auditory detection task.

Analyses focused on single-electrode event related potentials (ERPs) and oscillatory evoked responses respectively. Results suggest that, while single-electrode ERPs showed amplitude modulations as a function of sensor type, oscillatory responses were comparable. This was also true for voltage topographies.

The present comparison revealed that saline solution-based sensors represent a valid alternative to conventional gel-based EEG systems. Furthermore, application times of the high-density EEG solution was drastically reduced.

However, the results also revealed that when considering single-electrode ERPs saline-solution based sensors lead to smaller amplitudes compared to gel-based sensors. We hypothesize, that the observed difference can be related to the difference in conductive medium (i.e. electrolyte gel versus KCl-imbued sponges).

Methods

M21

Adaptive LDA Classifier in Brain-computer interface for decoding imagined syllables

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Brain-Computer Interfaces (BCI) aim to establish a pathway between the brain and an external device without the involvement of the motor system by using neurophysiological brain signals exclusively. In our research, we are developing a BCI system that can effectively decode imagined speech units (here two syllables) directly from Electroencephalography (EEG) signal. Static classifiers are normally used in BCIs. However, the EEG signal is highly non-stationary, potentially decreasing classification accuracy. This phenomenon could be responsible of a poor feature separation between two classes that we have observed using a Linear Discriminant Analysis (LDA) classifier without parameters' update. To address this issue, we have developed an adaptive LDA classifier (Schlögl, Vidaurre, and Müller 2009) able to extract properties of new incoming EEG signals and update itself on-line (i.e. in real-time). To do so, we have first identified, with offline simulations, the optimal parameters to update the adaptive LDA classifier, i.e., the Update Coefficient (UC) for the mean and the covariance matrix. By choosing the optimal UC, we could find a significant increase in the predicted accuracy for the simulated analysis (0.61 ± 0.01 with adaptation, 0.54 ± 0.01 without adaptation, chance level at 0.5). In addition, the adaptive LDA classifier could separate the two classes of the new EEG data better, compared to the static LDA classifier. These offline preliminary results will be applied to BCI online session in the near future and will provide a valuable tool to the development of effective non-invasive speech BCIs.

T1

Association between brain patterns of socio-emotional reactivity and Alzheimer's disease biomarkers in healthy older adults

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Alzheimer's (AD) is a neurodegenerative disease characterized by biomarkers including amyloid-beta and tau depositions, brain atrophy, glucose hypometabolism, and disrupted functional connectivity patterns that can co-occur many years before the manifestation of clinical symptoms. While later stages of AD typically affect a large part of cognitive and behavioral domains, recent evidence suggests that very early dysfunction of emotional reactivity may precede the onset of cognitive decline in AD. Here, we combined multimodal neuroimaging data from a large sample of healthy older adults (N=127) to elucidate the relationship between AD preclinical biomarkers and affective-related brain reactivity and recovery obtained with the SoVT-Rest fMRI task. First, we found significant effects of amyloid-beta depositions on positive and negative self-reported affect related to social distress. Also, using k-means clustering analysis, we found specific associations between post-emotion functional connectivity patterns and preclinical biomarkers associated with high risk for AD. While further research is needed, these post-emotion connectivity patterns may represent a new functional biomarker, particularly reflecting poor resilience and social stress regulation associated with neurodegenerative diseases.

Emotion & Motivation

T2

Affective touch and eye contact: hedonic and autonomic responses

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Affective touch plays a powerful and evolutionary fundamental role in human life: thanks to dedicated neural afferents, it produces calming effects, promotes social bonding and strengthens affiliative behaviors. Interpersonal touch has the unique property of being reciprocal; it entails a person promoting the touch and a person receiving the touch. While several studies have investigated the beneficial effects of receiving an affective touch, the affective experience of caressing another individual remains largely unknown.

We investigated with an ecological interactive paradigm how the experience of caressing another person differs according to the relationship between the two people involved. We asked whether stroking the partner is more pleasant than stroking a stranger and whether it elicits different autonomic responses. Furthermore, we compared subjective ratings of pleasantness and physiological responses when the affective touch was combined with a mutual eye contact.

Stroking the partner had the highest degree of pleasantness, especially if the touch occurred during mutual eye contact. Stroking the partner showed a greater decline in respiratory frequency, heart rate and skin conductance, suggesting a greater calming effect compared to stroking a stranger. On the contrary, stroking a stranger resulted less pleasant and produced higher arousal, indicating that hedonic and autonomic aspects of affective touch are modulated by social relationships.

These results support an instrumental role of interpersonal touch: people are more prone to caressing beloved ones and the high pleasantness of giving touch along with specific autonomic responses may promote affective tactile interactions among romantic partners, thus reinforcing their social bonding.

Neural circuits of psychosocial stress in anxious adolescents

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Adolescence is a critical period characterized by intense physical and psychological changes and maturation. It is a period of heightened stress reactivity and protracted development of regulatory brain regions, considered a vulnerable period for mental health. In order to examine the neural responses to acute psychosocial stress, we used a modified version of the Montreal Imaging Stress Task (MIST) in a group of 67 adolescents between ages 13 to 15 years old. The task consisted of an acute stressor (difficult mental calculations) ending with a positive or negative social evaluative feedback, followed by a 90 second recovery period with eyes closed. Control condition had easy calculations with a neutral feedback. During social feedback, we observed strong activity in right anterior prefrontal cortex, anterior insula and thalamus compared to control condition. Negative feedback compared to a positive one showed increased dorsal posterior cingulate cortex (PCC) activity in more anxious individuals, and higher activity in ventral PCC correlated with higher depression scores. In all participants, the recovery period after a negative feedback showed prolonged activation in anterior cingulate cortex. These results show that early adolescents engage strongly the salience network during social feedback. They also react specifically to a negative comparison with their peers, in particular if they present higher levels of depression or anxiety. In conclusion, the modified MIST is an effective tool to investigate the effects of psychosocial stress, valence and recovery in adolescents, highlighting networks associated with symptoms that could be targets of clinical interventions.

Modulations of attention by virtual reality

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Prism adaptation (PA) is a rehabilitation method used to alleviate spatial deficits in patients with neglect after right hemispheric strokes. PA consists of a visuo-motor adjustment to a shift of the visual field induced by wedge prisms. PA induces behavioural changes, corresponding to a lateral spatial bias in the direction opposite to the prisms deviation, and functional neural modulation involving a shift from a right to a left hemispheric dominance for attention, particularly within the inferior parietal lobule. The aim of this project is to determine if a visuo-motor shift induced by an immersive virtual reality (VR) environment induces similar behavioral and neural modulations to those observed after standard PA. Four groups of healthy participants (N=57) underwent fMRI acquisitions during a visual detection task done before and after visuo-motor training. Each group performed a specific visuo-motor training of either VR with adaptation (Virtual-PA group), VR without adaptation (Mock virtual group), standard PA (PA group), or plain glasses (Mock group). Our results showed that participants in the two adaptation groups (Virtual PA and PA) had similar visuo-motor adjustments (i.e. lateral spatial bias in open loop pointing movements) and similar brain modulations in the left and right ventral attention system, mainly in the inferior parietal lobules. On the other hand, specific modulations in visual areas were observed in both groups that used VR. In conclusion, this study confirms that adaptation with VR induces similar behavioral and neural modulations. These findings present an essential first step before using virtual prism adaptation with patients.

EEG microstates as novel functional biomarkers for adult attention-deficit hyperactivity disorder

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Background: Research on the electroencephalographic (EEG) signatures of attention-deficit hyperactivity disorder (ADHD) has historically concentrated on its frequency spectrum or event-related evoked potentials. In this work, we investigate EEG microstates, an alternative framework defined by the clustering of recurring topographical patterns, as a novel approach for examining large-scale cortical dynamics in ADHD.

Methods: Using kmeans clustering, we studied the spatio-temporal dynamics of ADHD during rest condition by comparing the microstate (MS) segmentations between adult ADHD patients and neurotypical controls, across 2 independent datasets: the first dataset consisted of 66 ADHD patients and 66 controls, while the second dataset comprised of 22 ADHD patients and 22 controls and was used for out-of-sample validation.

Results: Spatially, ADHD and control subjects displayed equivalent MS topographies (canonical maps), indicating preservation of prototypical EEG generators in ADHD. However, this concordance was accompanied by significant differences in temporal dynamics. At the group level, and across both datasets, ADHD diagnosis was associated with longer mean durations of a fronto-central topography (D), indicating its electrocortical generator(s) could be acting as pronounced “attractors” of global cortical dynamics. Lastly, in the first (larger) dataset, we also found evidence for decreased time coverage and mean duration of microstate A, which inversely correlated with ADHD scores, while microstate D metrics were correlated with sleep disturbance, the latter being known to have strong relation with ADHD.

Conclusions: Overall, our study underlines the value of EEG microstates as promising functional biomarkers for ADHD, offering an additional lens through which to examine its neurophysiological mechanisms.

NeuroTin: a clinical trial on fMRI and EEG neurofeedback versus group cognitive behavioral therapy (CBT) for chronic tinnitus

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Tinnitus affects roughly 1 in 10 adults in the US and is characterized by an aversive noise perceived in one or both ears, or more generally within the head, greatly impairing quality of life. It has been associated with excess auditory activation, as measured by fMRI, and reduced alpha band and increased delta band powers in the auditory cortex, as measured by encephalography (EEG). Our previous pilot study (Haller et al., 2009) has shown that neurofeedback (NF) training may improve volitional self-control of auditory activation and reduce tinnitus symptoms. We built up on this work with our recent clinical trial (NeuroTin) supported by the Wyss Center, where we investigated whether extensive neurofeedback therapies could outperform group cognitive behavioral therapy (CBT) in terms of tinnitus distress alleviation, and if chronic tinnitus sufferers could successfully learn to down-regulate brain activity related to auditory cortex. Three separate arms were opened with at least 20 participants in each: group CBT, fMRI NF, and EEG NF. CBT groups underwent 10 group sessions with a therapist at the Geneva University Hospital, whereas NF groups attended 15 sessions at the research facilities at Campus Biotech (Geneva). In fMRI NF, primary auditory cortex was delineated for targeted down-regulation, while in EEG NF, participants trained to up-regulate the ratio of alpha to delta band powers. We present detailed technical methodologies, and available clinical, neuroimaging, and experimental results for all arms. We further position NF approaches with respect to CBT, and provide insights into the future of tinnitus care.

Mindfulness-based intervention in preterm young adolescents: benefits on neurobehavioural functioning and its association with white-matter microstructural changes

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Very preterm (VPT) young adolescents are at high risk of executive, behavioural and socio-emotional difficulties. Previous research has shown significant evidence of the benefits of mindfulness-based intervention (MBI) on these abilities. This study aims to assess the association between the effects of MBI on neurobehavioral functioning and changes in white-matter microstructure in VPT young adolescents who completed an 8-week MBI program. Neurobehavioural assessments and multi-shell diffusion MRI were performed before and after MBI in 32 VPT young adolescents. Combined diffusion tensor imaging (DTI) and neurite orientation dispersion and density imaging (NODDI) measures were extracted on well-defined white matter tracts (TractSeg). A multivariate data-driven approach (partial least squares correlation) was used to explore associations between MBI-related changes on neurobehavioural measures and microstructural changes. The results showed an enhancement of global executive functioning after MBI that was associated with a general pattern of increase in fractional anisotropy (FA) and decrease in axonal dispersion (ODI) in white-matter tracts involved in executive processes. Young VPT adolescents with lower gestational age at birth showed the greatest gain in white-matter microstructural changes after MBI.

T8

Quantitative functional brain mapping imaging using Arterial Spin Labelling for safe neurosurgery

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Arterial Spin Labelling (ASL) is a non-invasive MRI technique for a direct and quantitative measurement of the cerebral blood flow. It can be used for functional imaging as an alternative to the standard BOLD-fMRI. This work aims to assess the spatial specificity of functional-ASL (fASL) in respect to BOLD and in comparison with TMS. Thirty healthy volunteers performed a motor task in a 3T MRI, while BOLD and ASL were simultaneously acquired. TMS was performed in a separate session.

For each subject and each hand, the coordinates of the global maxima for BOLD and fASL were collected at individual level and then compared with TMS. Paired-t-tests were performed between the two MRI modalities, to detect systematic shift.

Primary motor area was detected in all subjects ($p\text{-FWE}<0.05$) for both MRI modalities. Activation maps in fASL were better shaped on the known anatomical motor areas. A better match between fASL and TMS than between BOLD and TMS was observed.

Paired-t-test showed significant difference ($p<0.001$) between ASL and BOLD localization in z-direction, indicating that fASL systematically localizes deeper than BOLD, along the central sulcus. Along y-direction, fASL had a tendency ($p=0.048$) to localize more anteriorly than BOLD. No significant shift was observed along x-direction.

Our results show that fASL follows the expected anatomical structures better than BOLD, whose main cluster extended over the somatosensory cortex. The systematic comparison with TMS, should confirm the better specificity of fASL over BOLD. fASL will be particularly beneficial for mapping eloquent cortex during presurgical workflow.

Musical and psychomotor interventions for cognitive, sensorimotor, and cerebral decline in patients with Mild Cognitive Impairment (COPE): a study protocol for a multicentric randomized controlled study

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Background: Regular cognitive training can boost or maintain cognitive and brain functions known to decline with age. Most studies administered such cognitive training on a computer and in a lab setting. However, real life activities, like musical practice or physical exercise that are complex and variable, could be more successful at inducing transfer effects to different cognitive domains and maintaining motivation. "Body-mind exercises", like Tai Chi or psychomotor exercise, may also positively affect cognitive functioning in the elderly. We will investigate the influence of active music practice and psychomotor therapy over 6 months in Mild Cognitive Impairment patients from university hospital memory clinics on cognitive and sensorimotor performance and brain plasticity.

Methods: We aim to conduct a randomized controlled multicenter intervention study on 32 Mild Cognitive Impairment (MCI) patients (60-80 years), within 2 experimental groups: 1) Music practice; 2) Psychomotor therapy. Controls will consist of a passive test-retest group of 16 age, gender, and education level matched healthy volunteers.

The training regimens take place twice a week for 45 minutes over 6 months in small groups, provided by professionals, and patients should exercise daily at home. Data collection takes place at baseline, 3, and 6 months after training onset, on cognitive and sensorimotor capacities, subjective well-being, daily living activities, and via functional and structural neuroimaging.

Discussion: The purpose of this study is to investigate whether small-group musical practice or psychomotor training may improve MCI patients' cognitive, sensorimotor, and brain function and structure, hence enhancing their daily life functioning and well-being.

Gelotophobia and the brain - neural correlates during social signal processing

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Laughter is a frequent social signal with a predominantly positive emotional connotation. Beyond social inclusion, it can also communicate social exclusion. Interindividually, the perception of laughter is variable and can be phobic in extreme cases. This phobia, termed gelotophobia, is defined as the specific fear of being laughed at. First clinical studies indicate an increased co-occurrence of this phobia with various psychiatric disorders and corroborate a relationship with social anxiety. However, the neural representation of this fear remains unexplored to date.

We report a first fMRI study delineating the neural representation of gelotophobia during voice and face processing in 67 individuals.

The results revealed positive correlations between the severity of gelotophobic symptoms and voice-preferential responses in the right temporal voice area (TVA), a central node of the voice processing system, and in the left amygdala. In contrast, face-preferential responses were not associated with gelotophobia. The correlation between gelotophobia and voice-preferential responses in the TVA remained significant after accounting for general as well as social anxiety or depressive symptoms. In contrast, in the amygdala the association of voice-preferential responses with gelotophobia was not significantly dissociable from that with social anxiety.

Taken together, our study offers a first account of the neural representation of gelotophobia and additionally highlights the central role of voices and voice processing for this condition and its neural underpinnings. Particularly, the response patterns of the right TVA point to a specific contribution of this voice processing area not attributable to symptoms of social or general anxiety or depression.

Neural processing of benevolent, tickling and taunting laughter in disruptive behavior disorders

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Introduction: Human laughter is a powerful means of communicating social intention, from benign and welcoming to hostile and ridiculing. Misattribution of such social intention of others is associated with maladaptive psychosocial development, particularly aggressive behavior. **Method:** The current study investigated the role of physical aggression (PA) and callous-unemotional (CU) traits among youth with disruptive behavior disorders (DBD; N = 46; 22 female; 14.8 (1.9) y) compared to an age and sex-matched control group (CG; N = 46; 22 female; 14.2 (2.1) y) in the interpretation and neural processing of different types of laughter using fMRI. **Results:** DBD attributed more hostile social intention towards benevolent laughter than CG ($F(2,88) = 3.66$, $p = .05$). Neurobiologically, DBD showed increased BOLD response during laughter processing in right inferior parietal and temporal gyrus (DBD > CG; $k > 106$; $T > 4.27$, $p\text{-FWE} < .049$), particularly the fusiform gyrus among males. Right superior temporal gyrus activation increased parametrically with behavioral hostile attributions. In CG, this effect was positively related to PA and CU ($r\text{-PA} = 0.45$; $r\text{-CU} = 0.25$), while showing opposing relations in DBD ($r\text{-PA} = -0.38$; $r\text{-CU} = 0.27$). **Discussion:** A tendency to overattribute hostile intention to benevolent social stimuli in DBD may underlie heightened reactive PA, reducing the likelihood of positive social interaction. Neurobiologically, heightened activation in socioemotional processing areas, particularly face processing nodes, indicate DBD do not engage less with signals of social intention, but may rather have difficulty processing and thereby assigning social intention to these.

EEG state space descriptors, EEG microstates quantifiers and their temporal dynamics in intraoperative multichannel EEG: Secondary exploratory analysis of a randomized controlled trial

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Background: EEG microstates and EEG global state space descriptors assumingly quantify functional states of large-scale neuronal networks. To date, these parameters and their changes during anesthesia have not been studied. Aim of this study was to analyze these EEG features in patients with and without postoperative delirium (POD).

Methods: Altogether, 887 artefact-free 1-minute intervals, of these 294 (33%) intervals in isoelectric EEG / burst suppression (BS), derived from 73 intraoperative multichannel EEGs from the randomized controlled Surgery Depth of Anesthesia and Cognitive outcome (SuDoCo)-study (SRCTN 36437985) were analyzed. State space descriptors (sigma, phi, omega) were evaluated as interaction of time of anesthesia, BS, and vulnerable brain (patients with POD). EEG microstates quantifiers (duration, occurrence, global field power) were evaluated as interaction of microstates, time of anesthesia, BS, and vulnerable brain. Analyses were by linear mixed effects models, adjusted for relevant confounder.

Results: The elderly (71 ± 7 years) and predominantly male (60%) patients received median 210 (range: 75-675) minutes anesthesia. During seven post-operative days, 21 patients (29%) developed POD.

All three state space descriptors were associated with interactions of anesthesia time, BS, and vulnerable brain. Microstate duration and occurrence were associated with interactions of microstates, anesthesia time and BS while solely microstate global field power was associated with the interaction of anesthesia time, BS, and vulnerable brain.

Conclusions: Under general anesthesia, multiple changes in global EEG parameter and in dynamics of microstates occur. These changes vary partly between patients with and without POD. Their role in the onset of POD requires further investigations.

Teaching children suffering from ADHD to self-regulate their attention through virtual reality and EEG-neurofeedback

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There are several possible treatments to help children with attention-deficit hyperactivity disorder (ADHD) including psychostimulant drugs such as methylphenidate (Ritaline®) that are well-known to induce various side effects. Among the non-drug alternatives, the neurofeedback is a proven method, but its long term benefits depend on the number of training sessions done. Thus, our strategy was to combine the EEG-based neurofeedback method with immersion in a playful virtual classroom environment. The objective behind this was to boost the motivation and involvement of children, and thus drastically reduce the number of sessions needed. We also expect to see greater long-term benefits with this attractive and fun approach than with traditional EEG-neurofeedback trainings.

To evaluate the feasibility and effectiveness of the protocol in children, we first carried out this study on a small cohort of healthy children (between 6 and 10 years-old). They performed 8 EEG-neurofeedback session paired with virtual reality environment. During these sessions, children performed three different cognitive tasks, interleaved with three EEG-neurofeedback trainings based on theta/beta ratio. To detect potential changes in the strength of connectivity in attentional networks following EEG-neurofeedback training, we compared brain functional connectivity of children at rest using a simultaneous EEG-MRI session performed in pre- and post- training. Here, as a piloting study, we have conducted the entire protocol in two children. The whole procedure was very well-tolerated by the children who were highly motivated. This preliminary feasibility study demonstrates that this approach increases the motivation and involvement and can be envisioned in children with ADHD.

Stress markers and hippocampal dynamic connectivity in bipolar patients, their offspring, and healthy controls

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Bipolar disorder (BD) is a highly heritable, severe chronic affective disorder characterized by recurrent oscillations between mood states and increased vulnerability to stress. Hippocampus structural alterations and immune dysregulation have been associated with stress processing/reactivity in BD patients. However, the dynamic functional connectivity (dFC) of this region in BD remains unclear. The present study aims to explore interactions between hippocampal dFC, peripheral inflammatory markers and clinical scores of BD in offspring. We hypothesize that chronic inflammation and stress markers are associated with altered hippocampal dFC and clinical indices, in adolescent patients suffering from BD. To test this hypothesis, we will implement a co-activation pattern (CAPs) analysis of dFC on resting-state functional MRI data of 101 subjects (26 BD patients, 19 BD patients' offspring, and 56 healthy controls). Furthermore, we aim at reproducing the findings of altered hippocampal structure in this population through segmentation of hippocampal subfields using CAT12 in SPM12. Preliminary results will be presented at the conference. This project will contribute to advancing research into mechanisms of hippocampal alterations in BD, and to identifying markers of BD vulnerability, which could allow to mitigate the burden of BD by early identification and surveillance of vulnerable high-risk subjects.

Corpus callosum structural characteristics in very preterm children and adolescents: developmental trajectory and relationship to cognitive functioning

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Previous studies suggest that structural alteration of the corpus callosum, i.e., the largest white matter commissural pathway, occurs after a preterm birth in the neonatal period and lasts across development. The present study aims to unravel corpus callosum structural characteristics across childhood and adolescence in very preterm (VPT) individuals, and their associations with general intellectual, executive and socio-emotional functioning. Neuropsychological assessments, T1-weighted and multi-shell diffusion MRI were collected in 79 VPT and 46 full term controls aged 6 to 15 years. Volumetric, diffusion tensor and neurite orientation dispersion and density imaging (NODDI) measures were extracted on 7 callosal portions using the TrackSeg software. A multivariate data-driven approach (partial least squares correlation) and an age normative modelling approach were used to explore associations between callosal characteristics and neuropsychological outcomes. The VPT and a full-term control groups showed similar trends of white-matter maturation over time, i.e., increase FA and reduced ODI, in all callosal segments, that was associated with increase in general intellectual functioning. However, using age-related normative modelling, findings show atypical pattern of callosal development in the VPT group, with reduced callosal maturation over time that was associated with poorer general intellectual and working memory functioning, as well as with greater prematurity.

Large-scale functional network dynamics in human callosal agenesis: increased subcortical involvement and preserved laterality

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In the human brain, the corpus callosum is the major white-matter commissural tract enabling the transmission of sensory-motor, and higher level cognitive information between homotopic regions of the two cerebral hemispheres. Despite developmental absence (i.e., agenesis) of the corpus callosum (AgCC), functional connectivity is preserved, including interhemispheric connectivity. Subcortical structures have been hypothesised to provide alternative pathways to enable this preservation. To test this hypothesis, we used functional Magnetic Resonance Imaging (fMRI) recordings in children with AgCC and typically developing children, and a time-resolved approach to retrieve temporal characteristics of whole-brain functional networks. We observed an increased engagement of the cerebellum and amygdala/hippocampus networks in children with AgCC compared to typically developing children. There was little evidence that laterality of activation networks was affected in AgCC. Our findings support the hypothesis that subcortical structures play an essential role in the functional reconfiguration of the brain in the absence of a corpus callosum.

Neuropsychological evidence of long-term limbic system dysfunctioning following SARS-CoV-2

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Long term disorders in memory and emotional processing have been observed in SARS-CoV-2 patients. The aim of this study was to investigate whether COVID-19 causes emotion recognition and memory deficits (6-9 months after the acute phase), and to determine whether the presence of these disorders is correlated with the severity of the disease and the presence of neuropsychiatric disorders.

105 patients were recruited and divided into 3 groups according to the severity of respiratory symptoms during the acute phase (severe: N = 24; moderate: N = 39; mild: N = 42). Participants performed neuropsychological tasks investigating memory systems, emotion recognition, as well as an olfactory test and several psychiatric questionnaires. The three groups were compared using Kruskal-Wallis tests. Correlations and mediation analysis were performed to investigate links between psychiatric/olfactory and emotional/memory data. A multivariate partial least squares correlation (PLSC) approach was used to identify shared patterns of functional brain connectivity and emotion recognition abilities.

Moderate patients showed difficulties in fear recognition while severe patients displayed worse performances for disgust and irritation decoding. Mild patients presented better performances in memory tasks which were partially mediated by anxiety scores. Latent components from the PLSC analysis showed implications of the limbic system in association with the emotion recognition process.

This study argues in favor of damage to the central nervous system and possibly to the limbic system by SARS-CoV-2. Emotional and memory deficits observed support the hypothesis of interoception disturbances through damage of the insular cortex.

The severity of autistic symptoms is negatively correlated with functional connectivity to the frontal cortex during laughter perception

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Introduction

Laughter is a very powerful social signal to express acceptance or rejection. Adults with high functioning autism (HFA), however, show a tendency to interpret laughter as less benign as compared to typically developed controls. Here, we examined the impact of the severity of autistic symptoms on cerebral activation and connectivity patterns during laughter perception.

Methods

31 volunteers participated in the study (age 30.7 ± 9.9 years, nfemale = 14). 10 participants fulfilled the criteria for HFA diagnosis according to ICD-10, whereas the other 21 participants reported no past or present neurological or psychiatric disorders. Current ASD symptom severity was determined using the Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001).

During fMRI-measurements (3T) participants rated laughter-sequences (60 video sequences) as friendly versus hostile in intent on a four-point scale. Cerebral activation and connectivity was analyzed using SPM8.

Results

At behavioral level, a significant reduction of benign intent attributions correlated with AQ scores. Regarding cerebral activation, a negative association was found between BOLD response in the right inferior frontal gyrus during laughter perception and AQ score. Moreover, AQ-dependent negative modulations of functional connectivity to the frontal cortex were observed for the bilateral fusiform face area as well as the right temporal voice area. These alterations in cerebral connectivity within the social perception network might underlie the deficits in social cue processing in subjects with HFA.

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Temporal organization of goals along the hippocampus axis

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Our brain has to manage multiple goals that differ in their temporal proximity. Some goals have already been accomplished, others require immediate attention, and others will be relevant later in time. Here, we examined how the hippocampus represents the temporal distance of different goals using a novel paradigm in which participants are sent on a mission to Mars during a 7T fMRI. The hippocampus has an established role in cognitive mapping and a system in place to stratify information along its longitudinal axis on the basis of representational granularity. While fine-grained information is represented in the posterior hippocampus, coarse, gist-like information is represented in the anterior hippocampus. We tested whether the hippocampus uses these same organizational principles to map goals according to their temporal distance. We hypothesized that the hippocampus distinguishes relevant goals to current needs from those that are removed in time along the long axis, with temporally removed past and future goals eliciting increasingly anterior activation. We sent participants on a Mars mission where they had to track a series of goals that differed in the timing of their completion. Consistent with long-axis theories, temporally removed past and future goals activated the left anterior hippocampus, whereas current goals were activated more posteriorly in the left medial hippocampus. This work demonstrates that the timestamp attached to a goal is a key factor in how the goal is processed and represented in the brain. Furthermore, this work extends the scope of the hippocampal long axis system to the goal-mapping domain.

EEG correlates of bodily self-consciousness during spatial navigation

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Bodily self-consciousness (BSC) refers to the experience of being located within a body occupying a specific location in space. BSC depends on the successful integration of multisensory and sensorimotor cues, and it can be experimentally altered using immersive Virtual Reality (VR) technologies combined with online multisensory stimulation. BSC alterations have been shown to impact several cognitive functions, including spatial navigation and its neural correlates (Moon et al., 2020). However, the full impact of BSC on spatial navigation and the electrophysiology of the associated neural signals remained unexplored. Here, we addressed this issue using a well-known BSC manipulation, the full body illusion (FBI), while subjects performed a spatial memory task in immersive VR. High-density surface EEG recordings were simultaneously acquired. During the FBI, participants received tactile stimulation on the back while viewing a virtual avatar being synchronously stroked. This manipulation elicits self-identification with the virtual avatar and induces a replicable drift in the experienced self-location towards it. Following the illusion, participants performed a navigation task consisting of memorizing and recalling the location of several objects within a virtual arena. We observed a significant drift in recalled location when navigating with the avatar, and a better behavioral performance in the illusory BSC condition compared to the control condition. EEG correlates of both illusory and navigation periods were altered by the BSC manipulation. In summary, our data show that BSC, experienced self-location, and spatial memory are closely linked together, and represent the first electrophysiological investigation of the neural substrates of their interplay.

Two-dimensional adaptation of decision variability to reward volatility and trait compulsivity

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The variability of reward-guided decisions arises from two distinct sources: imprecise reinforcement learning due to limited resources, and exploratory choices aimed at reducing uncertainty. But whether these two sources of decision variability adapt to specific forms of uncertainty remains unknown. Here we designed a two-armed bandit task in which we compared the effects of reward stochasticity and volatility on decision variability. Across three datasets (total N = 447 participants and 262,560 decisions), we show that humans decrease learning noise and make more exploratory choices in response to volatile but not stochastic rewards. Through theoretical simulations, we demonstrate that these selective effects reflect cost-efficient adaptations to uncertainty. We further show that individual differences in trait compulsivity, measured using a validated transdiagnostic approach, account for variations in exploration but not learning precision. Together, these findings reveal a latent two-dimensional trade-off regulating decision variability under uncertainty.

Neural correlates of predictive processes in the infant brain

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The infant brain is an exceptionally efficient learning machinery, able to extract complex knowledge by mere exposure to a noisy and ambiguous environment, typically devoid of any explicit feedback. Over the last few years, a new vision of cognitive development has emerged to account for these early accomplishments, postulating that infants actively generate predictions about their environment, and revise these predictions in the light of sensory input to derive knowledge. Despite a wealth of literature supporting this perspective at the behavioral level, it remains unclear whether and how this strategy is implemented at the neural level. To address this question, we present 4-month-old infants with a cross-modal cueing paradigm in which auditory cues acted as predictive signals about upcoming visual events. Combining the respective advantages of mismatch and omission protocols, we recorded electroencephalographic responses to predictive and non-predictive sounds, expected and unexpected images, as well as expected and unexpected visual omissions. Preliminary analyses indicate the presence of mismatch responses to unexpected images, as well as anticipatory signals preceding expected images. These preliminary results provide evidence that predictive processes are already functional in the maturing infant brain.

Episodic autobiographical memory for virtual scenes is modulated by sensorimotor synchrony and the sense of agency during encoding

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Episodic autobiographical memories (EAM) are contextual memories of personal events. Their formation is impacted by self-related encoding context. Recent work using virtual reality (VR) showed that EAM strength is modulated by the experience of one's own body viewed during an incidental task involving a motor action. Such modulation may involve the first-person perspective but also the sense of agency (SA) over performed actions.

Leveraging immersive VR with functional Magnetic Resonance Imaging (fMRI), we coupled the incidental encoding of virtual rooms with the manipulation of the visuomotor synchrony: healthy participants experienced either synchronous or asynchronous movements of a first-person avatar with respect to the actual, online-tracked arm movement, and reported their SA. One hour later, participants performed an object-change recognition memory. fMRI was recorded during both encoding and recognition. We hypothesized that visuomotor synchrony would enhance SA and improve encoding. This should in turn enhance recognition memory and brain activity in both Medial Temporal Lobe (MTL) and the brain network processing multisensory congruence and the SA.

During encoding, participants felt significantly more agent of their actions in the synchronous than asynchronous condition. The premotor cortices, the right temporoparietal junction and the intraparietal sulci were more activated by synchronous condition, and premotor activity correlated to SA. During recognition, we observed that the synchronous conditions resulted in better object-change detection. This behavioral change was correlated to premotor, left perirhinal, and parahippocampal activity change. Thus, MTL and sensorimotor regions are coupled during memory formation, providing a neural substrate for sensorimotor-mediated bodily modulation of EAM.

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Electrophysiological correlates of recognition memory vary according to signal detection theory components and decisional factors

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The human memory appears to have almost infinite capacity. However, behavioral and electrophysiological studies of recognition have essentially been performed using forced-choice tasks, barring the distinction with signal detection theory (SDT). Two models of recognition memory resulted from those studies: a two-factor model, where correct recognition reflects the contribution of familiarity and recollection (by posterior regions and frontal cortex respectively) and a one-factor model that remains controversial.

Here we seek to identify electrophysiological markers of recognition memory using a “yes-no” task. Twenty-two participants were asked to identify 360 images seen 24 hours ago, mixed with 360 foils, while a 128-channels EEG was recorded. SDT responses yielded 4 conditions: Hit, Miss, Correct Rejection and False Positive. To determine electrodes and time windows of interest, we first conducted a non-parametric repeated-measure ANOVA across all electrodes, timeframes and conditions. Three ROIs (posterior left, posterior right, central) and one time-window (470 to 670ms) returned significant differences. Post-hoc analyses revealed that conditions significantly affected ERPs. Hits and False Positives (i.e., answer “yes”) caused greater deflections than Misses and Correct Rejections in given ROIs. Cluster analyses revealed that Hits contrasts with the other conditions, while Misses and Correct rejections were strongly similar.

Our study suggests that neither the one-factor, nor the two-factor model is sufficient to reflect both memory and decisional processes underlying recognition memory. Electrophysiological traces strongly differ according to response type (“yes” vs. “no”), suggesting that not only familiarity/recollection influence recognition, but so do decisional output components.

Far from the eyes, far from the heart. COVID-19 confinement dampened sensitivity to painful facial features

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In the last two years, governments of many countries imposed heavy social restrictions to contain the spread of the COVID-19 virus, with consequent increase of bad mood, distress, or depression for the people involved. Few studies investigated the impact of these restrictive measures on individual social proficiency, and specifically the processing of emotional facial information, leading to mixed results. The present research aimed at investigating systematically whether, and to which extent, social isolation influences the processing of facial expressions. To this end, we manipulated the social exclusion experimentally through the well-known Cyberball game (within-subject factor), and we exploited the occurrence of the lockdown for the Swiss COVID-19 first wave by recruiting participants before and after being restricted at home (grouping factor). We then tested whether either form of social segregation influenced the processing of pain, disgust or neutral expressions, across multiple tasks probing access to different components of affective facial responses (state-specific, shared across states). We found that the lockdown (but not game-induced exclusion) affected negatively the processing of pain-specific information, without influencing other components of the affective facial response related to disgust or broad unpleasantness. In addition, participants recruited after the confinement reported lower scores in both empathy questionnaires and affective assessments of Cyberball co-players. These results suggest that social isolation affected negatively individual sensitivity to other people's affect and, with specific reference to the processing of facial expressions, the processing of pain-diagnostic information.

Differential dorsal and ventral putamen oscillatory responses to angry voices according to attentional focus in epileptic patients.

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Several neuroimaging studies have implicated the human putamen in vocal emotion decoding. Interestingly, left-putamen activation has been reported more specifically when the participant's attentional focus is targeted at the emotional content of angry utterances (explicit processing). However, as the putamen is inaccessible to non-invasive EEG methods and is not recognized as a routine deep-brain stimulation target, the human electrophysiological correlates of emotional voices decoding in this structure are so far unknown.

Here, we report the intracranial event-related potential (ERP) recordings from 4 epileptic patients with electrodes presenting contacts within the left (1 patient, 4 contacts) or right putamen (3 patients, 9 contacts), who were presented with angry and neutral voices with an explicit (emotion-recognition task) or implicit (gender recognition task) attentional focus (2 sessions). In the right putamen, a dorsal-ventral response-segregation was observed in terms of attentional focus: ventral contacts presented an angry-versus neutral voices ERP dissociation specifically in the implicit setting while dorsal contacts presented a similar dissociation specifically in the explicit setting. Furthermore, these dissociations occurred around the same timings (~500ms after sound onset, ~100ms before mean sound offset) and were predominantly observed at the first session showing that these dissociations were prevalent during the acquisition phase of the task. The left putamen contacts (located in the dorsal section of the nucleus) presented also a later (750ms post-sound) angry-versus neutral voice ERP dissociation specifically in the explicit setting.

These results altogether provide the first insight into intricate oscillatory striatal responses to emotion, attentional, and learning processes.

Neural spiking activity in the human medial temporal limbic system to emotional whispered voices

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Human vocalizations are rich in social information, including emotional states, encoded within the acoustic signal. In some contexts, degradation of this signal occurs at the point of production, like for whispered vocalizations. Switching from normal voice to whispers can happen when secrecy or privacy is needed, and the brain of the listener must adapt rapidly. We hypothesize that successful decoding of emotional whispering is mediated by the hippocampal formation, feeding back additional information retrieved from long-term memory (e.g. previous experience, template matching) into the broader medial temporal limbic system. Using intracranial EEG, we recorded neural spiking activity from the amygdala and the hippocampal formation of 14 epileptic patients whilst they listened to whispered and normal voices expressing emotional or neutral states. Analysis shows that trial-averaged firing rates of neurons recorded in bilateral amygdalae were significantly different depending on the emotion and the vocal conditions. When comparing whispered to normal vocalizations, firing patterns in the right amygdala showed a significant peak offset. The left amygdala also unveiled a sensitivity to vocal condition with a spiking activity elicited by whispers expanded in time and magnitude compared to normal voices. Furthermore, whispered voices evoked transitory differential firing patterns in the bilateral posterior hippocampus, and a peak activity offset in the right anterior hippocampus. These results suggest increased functional interactions between the amygdala and the hippocampus during degraded affective speech perception. The decoding of socially relevant acoustic signals hence appears to benefit from the functional support of these two regions in challenging situations.

Emotion & Motivation

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Disrupting inferior frontal cortex activity alters affect decoding efficiency from clear but not from ambiguous affective speech

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The evaluation of socio-affective sound information is accomplished, among other brain regions, by the primate neural auditory cortex in collaboration with limbic and inferior frontal brain nodes. For the latter, activity in inferior frontal cortex (IFC) is often observed during the classification (e.g., categorization) of voice sounds, especially if they carry affective information. Partly opposing—yet not mutually exclusive—views have been proposed, with IFC either coding cognitive processing challenges in case of sensory ambiguity or representing categorical object and affect information of unambiguous vocalizations. Here, we presented clear and ambiguous affective speech to two groups of human participants during neuroimaging, while in one group we inhibited right IFC activity with transcranial magnetic stimulation (TMS) prior to brain scanning. Inhibition of IFC activity led to partly faster affective decisions, more accurate choice probabilities and reduced auditory cortical activity for clear affective speech, while fronto-limbic connectivity increased for clear vocalizations. This indicates that IFC inhibition might lead to a more intuitive and efficient processing of affect information in voices. Contrarily, normal IFC activity might represent a more deliberate form of affective sound processing (i.e., enforcing cognitive analysis) that flags categorial sound decisions with precaution (i.e., representation of categorial uncertainty). This would point to an intermediate functional property of the IFC between previously assumed mechanisms.

Apathy following COVID-19 infection: a single-case with clinical, DaTSCAN and resting-state electroencephalographic data

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Neuropsychological symptoms following COVID-19 infection have been a recent concern due to their impact on health and society. Emotional apathy has recently been identified as a post-COVID-19 symptom. Mechanisms underlying post-COVID-19 neuropsychological symptoms remain unclear. While recent meta-analyses point to generalized slowing of EEG rhythms with the emergence of strong delta rhythms in severe hospitalized COVID-19 patients, no EEG study nor dopamine transporter scintigraphy (DaTSCAN) have been performed in long COVID patients following mild infection.

We hereby describe the case of a 47-year-old maintenance worker who developed emotional apathy following a mild COVID-19 infection. While he was very active prior to the infection (eg playing video games or with his children for hours), he dramatically lost interest in his leisure activities after COVID-19. Seven months after the infection, his neuropsychological testing demonstrated apathy, especially in the emotional domain, as well as a dysexecutive syndrome, moderate attentional and verbal episodic memory disturbances, without signs of anxiety or depression. His cerebral MRI and DaTSCAN were unremarkable. Resting-state EEG revealed a complex pattern of oscillatory abnormalities compared to a control group of 20 healthy participants, with a strong increase in whole scalp delta and beta band activity, as well as a decrease in alpha band activity. These effects were more prominent overall in the frontal-central-temporal regions. These results demonstrate the presence of widespread modifications of EEG oscillatory patterns in a long COVID patient following mild infection and support the hypothesis of a dysfunction in the cortical networks implicated in motivation.

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Decoding emotion regulation processes: A pilot fMRI study

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Multivariate pattern analysis (MVPA) or “decoded fMRI” has recently gained popularity in the neuroimaging community. Compared to standard univariate analyses, decoded fMRI allows to predict a given behaviour from neural activity. We performed a pilot study to test whether it is possible to predict emotional behaviours in healthy participants with fMRI. Five healthy volunteers underwent a visual emotional task. Two runs of 240 randomized stimuli were presented within 12 blocs of 10 negative pictures and 12 blocs of 10 neutral pictures. In the first run participants had to react normally to the negative stimuli, while in the second run they had to control their emotional response. They also had to rate their affect (valence and arousal) halfway through and at the end of each run. Images were selected from validated databases. Univariate analyses were conducted to identify brain areas involved in the task. A linear SVM with 5-fold cross-validation was used to build the classifier. Univariate analysis revealed increase neural activity for negative vs. neutral stimuli predominantly in the bilateral amygdala, supramarginal gyri, insula, orbitofrontal and ventromedial prefrontal cortex. We obtain an average accuracy of 67.6% for the overall classification of negative vs. neutral neural activity patterns. Individual performance ranged from 60% to 72%. Our results showed the effectiveness of our paradigm to robustly detect the brain regions involved in emotion regulation processes and to infer negative emotion processing from brain activity. This baseline classifier will be later use in a decoded neurofeedback experiment in a neuropsychiatric population.

Assess and restore body representations after stroke

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The continuous stream of multisensory information between the brain and the body during body-environment interactions is crucial to maintain updated the representation of the perceived dimensions of body parts, metric body representation (mBR), and of the space around the body (peripersonal space, PPS). Sensorimotor deficits can limit the flow of multisensory signals, thus suggesting possible distortions of mBR and PPS in patients with persistent sensorimotor deficits, as after stroke.

To test this suggestion, we evaluated potential distortions in mBR, PPS, and the explicit perception of the affected upper-limb in 60 chronic stroke patients with unilateral motor deficits. We also tested the effects of novel neurotechnological interventions providing rich sensorimotor stimulations on those possible distortions.

Patients showed alterations in mBR of the affected limb, characterized by an underestimation of the arm length and a distortion in the arm global shape.

PPS representation was also altered, with a reduced multisensory facilitation for stimuli presented around the affected limb. PPS deficits were more common in patients with right brain lesion (RBD) or reporting pain during motion.

RBD patients also presented a higher prevalence of altered perceptions towards the affected limb, which were associated with proprioceptive deficits and a lower cognitive profile.

Finally, we observed that sensorimotor stimulation significantly reduced distortions in the perceived arm length and the affected limb perceptions.

These results reveal quantifiable distortions of the affected upper-limb in post-stroke patients. Those distortions could be restored by neurotechnological interventions providing rich sensorimotor stimulation, even in the chronic phase of the disease.

Emotion & Motivation

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Movie-induced fear experiences modulate dynamically-occurring amygdala-CAPs

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Researching the neural basis of emotion with fMRI poses a challenge to the experimental design used. Facilitated by recent technological developments in the field however; new approaches using naturalistic elicitation methods, such as films, have gained increasing attention (Saarimäki, 2021). Films are designed to evoke a universal emotional response and their use as a reliable method of emotion elicitation has been confirmed empirically (Cowen & Keltner, 2017).

We put together short films with continuous emotion annotations to unravel dynamic brain states associated with fear during movie watching. FMRI data of 30 participants were analyzed for amygdala-related Coactivation Patterns (CAPs) and how their time course evolves over the stimulus in relationship with changes in fear. GLM revealed significant activation in the amygdala as a function of higher fear ratings. This cluster was used as a seed region to extract ten CAPs. The resulting brain states represent varied networks across the cortex, including the Salience and Default Mode Network, to be coactivated with the Amygdalae. The mean occupancy of all CAPs varied between 6.9 - 12.7% demonstrating varied brain states over time. We observe synchronization between participants during key events in the stimulus that are also associated with high fear.

Time-resolved methods such as CAPs provide a powerful tool to probe for emotion-related dynamic brain states while viewing movies. We show CAPs of the Amygdalae that contain large-scale functional networks in the brain and point to how these are modulated by the experience of fear.

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Functional networks from portrayed emotions in the movie Forest Gump: an fMRI innovation driven co-activation patterns study

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An important struggle in affective science is the elicitation of emotions in an experimental setting. Indeed, emotions are complex, dynamic phenomena that are difficult to elicit by simple task-based paradigms as traditionally used with functional magnetic resonance imaging (fMRI). Naturalistic movies as stimuli during fMRI offer a dynamic and realistic framework for the study of affective contents (Saarimäki, H. (2021)).

By using the publicly available StudyForrest dataset (<https://www.studyforrest.org>), we extracted innovation driven co-activation patterns (iCAPs) (Karahanoğlu, F. I. et al. 2015) from 3T fMRI data in fifteen healthy subjects watching the movie Forrest Gump. The timecourses derived from the iCAPs are to be analysed in relation to portrayed emotions (i.e. emotion displayed by the movie character), using previously validated ratings of the movie (Labs, A. et al. (2015)).

The decomposition of the fMRI data using iCAPs revealed rich and diverse networks, ranging from primary auditory and visual networks to networks associated with higher order functions such as the frontoparietal and salience networks. In addition, we observed frequent transitions and a relatively even distribution of states over time, which is to be expected in the setting of naturalistic stimuli (Van der Meer, J. N. et al. (2020)).

Further ongoing analysis on the time courses of these brain states will help us link these networks to portrayed emotions. This will give new insights into how portrayed emotions are processed in the brain in a dynamic, closer-to-life setting, more readily implemented by naturalistic movies than other more traditional ways to study emotions.

Perception

W10

Following the path to propofol-induced unconsciousness with EEG microstates

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Introduction: EEG microstates are being increasingly used to parse neuronal activity into a sequence of discrete spatiotemporal patterns of transient brain states. Here we hypothesize that microstate dynamics may be used to describe pathologies-induced brain states alterations and is therefore ideally suited to track brain activity along the path to unconsciousness during surgical anesthesia.

Objectives: Here we aim to discover simple yet informative and holistic microstate features that allow to detect transitions into altered states of consciousness.

Methods: We continuously recorded high-density EEG in 23 surgical patients from their awake state to unconsciousness, induced by step-wise increasing concentrations of intravenous anesthetic propofol. We preprocessed the data and extracted the corresponding microstate sequences for each patient during baseline (no injection of propofol) and at different levels of unconsciousness. We then extracted, for each condition and subject, features such as average duration, density of microstates.

Results: The results show that transitions from fully alertness to deep unconsciousness elicited by propofol-based surgical anesthesia are not linear but rather accompanied by an initial increase/decrease and subsequent decrease/increase in density/duration of microstates respectively, in a characteristic "U-shape", probably linked to a state of paradoxical excitation before the transition to unconsciousness.

Conclusions: The results demonstrate the importance of using microstates to describe transient brain states and support the idea that flexibly switching from one state to another is not due to random fluctuations of brain activity, but rather the result of a critical balance between stability and transitions as an expression of altered states of consciousness.

The phase of pre-movement sensorimotor oscillations predicts the subjective feeling of control for intracortical brain machine interface actions

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The subjective feeling of self-generation that arises when our actions match our intentions, termed sense of agency, is a cornerstone of self-awareness and causal reasoning. We investigated its neural bases in a tetraplegic individual who is a proficient user of an intracortical brain machine interface. Motor commands were recorded from the primary motor cortex, decoded, and translated into functional hand movements through a neuromuscular electrical stimulation system. We manipulated the congruency between the implemented action and motor commands, and asked the participant to explicitly rate his sense of agency. We hypothesized that slow neural oscillations, due to their role in orchestrating inter-areal connectivity, may affect the sense of agency by modulating the integration of afferent and efferent information. Indeed, we found that the phase of pre-movement 8 Hz oscillations in M1 predicted the participant's agency ratings. Single-unit analyses revealed that the optimal oscillatory phase for sense of agency is compatible with the phase of maximal cortical excitability in M1. By using an EEG-based brain machine interface protocol, we confirmed the link between sense of agency and the phase of pre-movement oscillations in healthy participants, and localised their source in motor and premotor areas. Furthermore, we identified the modulation of connectivity between such regions and parieto-occipital areas as a potential mechanism for the observed effect. These results highlight a link between sensorimotor oscillations and the cross-modal binding of afferent and efferent information, which may be extended from sense of agency to broader set of sensorimotor and cognitive functions.

Perception

W12

Perceptual Awareness Negativity - does it reflect awareness or attention?

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Are correlates of perceptual awareness observed early in the visual cortex, or rather late in the parieto-frontal regions? Recent work supports the former view by showing that Perceptual Awareness Negativity (PAN) - a negative ERP component observed at posterior brain regions around 200 ms after the stimulus presentation - is a robust correlate of consciousness. However, considering that PAN is very similar to the previously described ERP correlates of selective attention in terms of spatio-temporal features (e.g. N2pc; see Bola & Doradzińska, 2021), to what extent PAN reflects engagement of attentional resources remains a key question. In the present study we developed a procedure in which stimulus awareness and two aspects of visual attention - exogenous and endogenous - were manipulated orthogonally. Participants were presented with images of faces, which were either backward-masked or unmasked, characterized either by a fearful or a neutral expression, and defined either as targets or task-irrelevant distractors. Our analysis revealed that, across all conditions, PAN's amplitude was more negative in response to visible stimuli, in line with its interpretation as a correlate of consciousness. However, we found that PAN's amplitude was also more negative in response to faces that were fearful or defined as targets, which suggests it reflects involvement of exogenous and endogenous attention, respectively. In conclusion, our study shows that PAN is related to perceptual awareness, but it is not a "pure" and specific correlate of consciousness.

Perception

W14

Task-based functional coupling of intentional action

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Intentional action constitutes an important part of motor behavior, as this process is necessary in order to initiate and control different actions. Neuroimaging studies have shown that self-generated actions implicate the dorsal and ventral parts of the frontoparietal network (FPN). However, knowledge of the functional coupling between the FPN and other brain regions during intentional action remains limited. Using a multiband fMRI sequence, we here studied brain activations and functional connectivity (FC) of thirty right-handed healthy participants performing a finger tapping task while instructed to use a specific finger (condition Ext) or select one of four fingers randomly (condition Int). The task was performed in two separate runs each requiring different hand usage in an alternating order. Consistent with previous studies, we observed stronger activations of posterior parietal cortex and premotor regions when contrasting Int vs. Ext conditions. Interestingly, this contrast also revealed significant activations of medial occipitotemporal regions including the left lingual and right fusiform gyrus. Task-based FC analysis identified increased functional coupling among FPN regions. Taken together, our results reveal strong functional interactions within the FPN during the selection and planning of intentional action.

Perception

W15

Awareness, attention, and threats - exploring the limits of unconscious fear reaction

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The ability to quickly and effectively react in the face of danger is crucial for survival in a complex, unpredictable environment. Therefore it has been proposed that a detection of threatening events might occur already on unconscious stages of perception. However, it remains unclear whether an unconscious fear reaction can exceed an nonspecific arousal and be targeted to a particular stimulus, selected among other, not relevant events. Thus in the present study we investigated the ability of invisible signals of threat to selectively capture attention and engage cognitive resources. In the conducted experiment we presented participants with faces expressing either fear or a neutral emotional state. Faces were arranged in pairs and displayed for 16 ms. In half of the trials we suppressed their visibility using backward masking procedure. In order to track neural several stages of neural response to face stimuli we recorded the EEG signal and extracted event related potentials (ERP). Data analysis revealed that face-specific N170 component reacted to unconsciously perceived fearful faces, but we did not observe ERP makers of attentional prioritization (P2, N2), selective attention capture (N2pc) or engagement (SPCN), or higher order cognitive processing (P3) of subliminal fearful faces. Thus our results demonstrate that while signals of threat can be identified outside of awareness, they do not possess the ability to selectively attract or engage attention. These conclusions add to the discussion on subliminal origin of fear and on the capabilities and limitations of unconscious processing, suggesting that attentional reaction to threats requires consciousness.

Perception

W16

Efficient compression of sensory information during categorical decisions

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Perceptual decisions rely on a cognitive inference process that extracts the statistics of ambiguous sensory observations through imprecise computations. But theories diverge regarding whether this inference process integrates information in its native sensory space or in a compressed category space defined by current decision alternatives. Here we designed a visual categorization task in which we manipulated the ability of human observers to perform inference in sensory and category spaces. We found that human observers spontaneously integrate sensory information in category space by projecting it on the decision axis, upstream from inference. When observers are forced to integrate sensory information in its native space, they do so with lower precision and larger information loss. Magnetoencephalographic (MEG) brain activity shows compressed neural representations of stimulus and decision signals in conditions where observers perform inference in category space. Together, these findings indicate that humans mitigate the costs of imprecise inference by focusing limited resources on decision-relevant information.

Inferential errors downgrade the neural response and subjective assessment of pain in both self and others

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Witnessing another's pain is a common, if unfortunate, occurrence. Because pain is a quale, decisions made on another's behalf are couched in uncertainty. We hypothesized that individuals would display distinctions in uncertainty processing of one's own and another's pain. To examine our questions, we performed a model-based neuroimaging study ($n = 33$), inviting dyads to complete a decision-making task where we evoked uncertainty with the use of lotteries. One member of each dyad chose between sure and risky pain relief options, before assigning a price on her selection. Pain was then delivered based on its likelihood and intensity. Finally participants were asked to rate the delivered pain on a visual analog scale. Participants played 2 blocks of the game, where either they – or their peer – were the decision targets. Agents displayed increased risk-aversion; higher valuation; and inflated assessments on another's pain. Imaging analysis further revealed both own and vicarious neural pain responses were significantly dampened by pain prediction error and surprise. These inferential errors predicted lower pain ratings. Taken together, results suggest that; 1) individuals appear altruistic in the face of another's acute pain; 2) risk biases individual decision-making on another's pain towards sure options; 3) errors of inference dampen the neural response, and subjective reports on both own and other's pain. In summary, individual decision-making on others' pain may differ overtly from decisions taken for oneself, but the effect of hidden inferential errors on neural responses to pain and pain assessment do not appear target-specific.

Perception

W18

The cerebral integration of affective prosody and semantic information in speech perception : the case of sarcasm.

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Oral communication combines prosodic and semantic aspects that often contain affective information. How these aspects of language are integrated with each other at the behavioral and neural level is still poorly understood. We aim to shed light on this issue using functional Magnetic Resonance Imaging (fMRI) to investigate the functional connectivity between the relevant brain regions including Superior Temporal Gyrus and Sulcus (STG/STS), frontal regions such as Inferior Frontal Gyrus (IFG) and Orbito-Frontal Cortex (OFC) while participants are exposed to sarcastic or sincere situations in auditory modality. We expect the IFG-OFC and IFG-STG/STS to be strongly connected during the perception of sarcasm compare to the perception of sincerity.

Perception

W19

Investigating the roles of Fusiform Face Area and Occipital Face Area in Human Face processing: a real-time fMRI neurofeedback study

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According to the traditional hierarchical account of human face processing detection of faces is mediated by the occipital face area (OFA), a region believed to code for face feature extraction (eyes, nose, mouth). Subsequent face identity judgments are then facilitated by the fusiform face area (FFA) where the extracted features are integrated into a global face representation. In contrast, non-hierarchical accounts argue that face information is first coarsely expressed in the FFA (detection) after which information related to face features is provided by OFA through reentrant connections (recognition). Using real-time fMRI neurofeedback (NFB) we tested these opposing claims by training 22 healthy volunteers (experimental group), during two separate sessions to selectively enhance FFA and OFA activity, while they were engaged in a face detection/recognition task. Our results show that participants successfully enhanced OFA activity when compared to their own baseline as well as when compared to the OFA modulation of a yoked control group (N=20). Furthermore, while FFA activity of the experimental group did not surpass baseline, it did exceed the FFA activity of the control group. Lastly, preliminary behavioral results tentatively support the non-hierarchical view: enhanced FFA (but not OFA) activity predicted improved face detection and recognition. However, further analyses need to be conducted to more confidently confirm these initial findings.

Perception

W20

Forest before trees, or trees before forest? Detection of gist and objects in real-world scenes

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Temporal hierarchy of visual perception is still a matter of debate, with two main groups of theories - local-to-global and global-to-local - having clearly contradictory predictions concerning how it unfolds over time. However, it is still unclear which theoretical view describes visual perception more faithfully, as few studies compared them directly. Therefore, in the present study we directly compared the temporal aspect of the global and local level recognition (i.e. backgrounds and objects, respectively). We used images depicting either a natural (BN) or an artificial background (BA), with a single natural (ON) or artificial (OA) foreground object. Thus, scene images were either congruent (background and object from the same category) or incongruent (background and object from different categories). The experiment comprised four blocks and in each block one of the four scene characteristics was defined as a target. The goal of participants (N=38) was to press a button if the briefly displayed (64 ms) image complied with this prespecified criterion. The results showed that detection accuracy was higher for objects than for backgrounds and for congruent as relative to incongruent images; and that responses were faster to objects as relative to backgrounds, to congruent as relative to incongruent trials, and to natural as compared to artificial targets. Our study indicates that the visual system is able to classify local objects before global gist, which suggests that main elements of a scene can be recognized based on the feedforward sweep of activity.

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An ERP study of the influence of bodily resonances on emotional prosody perception

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Emotional prosody is defined as suprasegmental and segmental changes in voice and related acoustic parameters that can inform the listener about the emotional state of the speaker. While the processing of emotional prosody is very present in the literature nowadays, the mechanisms of embodied cognition in emotional voice perception are very little studied. Here we investigated the influence of induced bodily vibrations in the categorization of ambiguous emotional vocalizations in an event-related potential study. The factorial design included Vocal emotion [anger and fear] and Vibration [anger, fear, and none] as factors. Emotional vocalizations were morphed between a fearful expression with the speaker's identity-matching angry expression. Emotional congruent and incongruent vibrations were delivered on the skin through transducers placed close to the vocal cords. The main hypothesis was that induced bodily vibrations would constitute a potential interoceptive feedback that can influence the auditory perception of emotions. Moreover, it was expected that these effects would be greater for more ambiguous stimuli. Behavioural analyses showed that vibrations and emotional vocalizations had a significant effect on participants' responses, as their interaction did. In particular, participants categorized emotional vocalizations as anger more often for vibrations related to anger, compared to vibrations related to fear. ERP analysis showed early amplitude increase in frontal electrodes at vibrations onset and in central electrodes, around 500ms post vibrations onset. These results suggest that vibrations can play a role in the emotional vocal perception through an embodied perspective.

Children with autism exhibit stronger selective neural response to visual over speech features in a cartoon movie watching setting

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Children with autism spectrum disorder (ASD) often display atypical audio and/or visual perception under classical laboratory experimental conditions. Yet, studies exploring modality-specific neural response to continuous audiovisual stimuli are rare. In our study, children with (N=31, mean 3.09-years-old) and without (N=33, mean 2.92-years-old) ASD watched cartoons while their neural activities were recorded with electroencephalography (EEG). Here we used multivariate temporal response functions (mTRFs) to linearly link ongoing, continuous environmental signals to simultaneously recorded brain responses and delineate modality-specific neural responses. Speech envelopes and basic visual features of the scene, e.g., intensity contrast, color contrast, motion energies, etc., were extracted and then predicted from neural activities using the backward model of mTRFs. While children with and without ASD had equivalent responses to visual features, children with ASD exhibited weaker responses to speech. Notably, neural responses predicted more accurately speech than visual features in the TD, the effect was opposite in the group of children with ASD. In sum, while TD kids show dominant and more accurate responses to speech in natural audiovisual stimuli, we observed stronger neural selectivity to visual features than to the speech envelope in children with ASD, indicating a possible dominance of visual over audio modality during multimodal process. Such an imbalance in audio-visual processing neural activity may explain their difficulty in speech reception and oral communication.

Pre-stimulus alpha-band power predicts both objective task accuracy and subjective perceptual awareness

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At every moment multiple stimuli reach our senses but only some of them gain access to consciousness. Previous research has consistently shown that spontaneous activity of the visual cortex, in particular power of alpha-band oscillations (7-14 Hz) directly preceding a visual stimulus, predicts whether it will be perceived or not. However, considering that objective task performance and subjective conscious experience may be in principle dissociated, how alpha oscillations affect these two aspects of perception remains to be established. In the conducted experiment a Gabor patch, the contrast of which was adjusted individually for each participant (N = 103), was presented in one of four peripheral locations, and in one of the four possible orientations. In every trial, participants performed objective detection and identification tasks, and rated intensity of their subjective perception using the Perceptual Awareness Scale (PAS). The impact of pre-stimulus alpha power on tasks performance and subjective experience was modeled using linear mixed models on a single-trial level. We found that high alpha power before the stimulus onset (-250 ms to -100 ms) predicted worse accuracy in both detection and identification tasks. Further, high alpha power was also related to lower PAS ratings, indicating weaker subjective awareness. Importantly, we found the effects of accuracy and alpha-power on the PAS to be independent. In conclusion, by testing a big sample of participants and employing a single-trial analysis we were able to reveal that pre-stimulus alpha-band power predicts both objective task performance and subjective awareness.