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Ten years of Mind/Brain Sciences at the University of Trento

How the past can determine our future

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CIMeC, Rovereto, Italy



POSTER ABSTRACTS

FRIDAY- SESSION A (10:30-11:30)

1

Attentional influences on temporal processing

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Background: Constructing useful representations of our visual environment requires the ability to selectively pay attention to particular locations at specific moments. Whilst there has been much investigation on the influence of selective attention on spatial discrimination, less is known about its influence on temporal discrimination. In particular, little is known about how endogenous attention influences two fundamental and opposing temporal processes: segregation – the parsing of the visual scene over time into separate features, and integration - the binding together of related elements. Methods: We tested how endogenous cueing to a location influences each of the opposing temporal processes of segregation and integration, using a task in which task goal varies while visual stimulation is held constant. The ongoing dynamics of brain activity during the task were recorded with MEG. Results: Behavioural results demonstrate a strong cueing effect on both segregation and integration. These results support the hypothesis that endogenous attention can influence both of these opposing processes, effectively shrinking or expanding the integration window in line with task goals. Preliminary electrophysiological findings indicate differences in brain dynamics depending on current goals, as well as differences in activity in line with attentional deployment and behavioural correlates. The findings have implications for arbitrating between accounts of the multiple modulatory mechanisms comprising selective attention.

2

Preserving spelling in the brain tumor patients: Two cases spelled out

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Background: Awake glioma surgery aims to maximize tumor resection while preserving quality of life. Although spelling skills have become indispensable in personal and professional daily life, writing is scarcely assessed in neurosurgical practice. Lesion and neuroimaging literature distinguished multiple cognitive components underlying spelling, which result in specific error patterns when damaged. We examined how this knowledge could aid to predict and ultimately prevent spelling disorders after awake surgery. Methods: Two illustrative cases are reported. Spelling was assessed before and after surgery using a written language battery developed for glioma patients, which includes words, non-words and sentences, targeting all the components underlying spelling. Intraoperatively, case 1 (a 63-year-old right-handed female with a low-grade glioma in supramarginal gyrus) was assessed with spoken naming and reading; and case 2 (a 34-year-old right-handed female with a low-grade glioma in posterior middle frontal gyrus) was assessed with spoken naming and writing. Results: Spelling accuracy significantly declined post-operatively in case 1, affecting predominantly non-words. Segmental errors occurred in words, but qualitative features of spelling remained unaffected. Current literature involves supramarginal gyrus in phoneme-grapheme conversion and graphemic buffering. Accuracy did not significantly decline after surgery in case 2. Yet, both accuracy and qualitative features were impaired, predominantly on longer items. Literature involves the posterior middle frontal gyrus in graphemic buffer and peripheral processes. Significance: Observed error patterns are congruent with the literature, and intra-operative writing assessment preserved spelling after

surgery. Current knowledge may be used for detailed peri-operative testing, to predict outcome and to select items for intra-operative assessment.

3 Eye movement patterns in response to social and non-social cues

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Background: *Gaze* and *arrow cues* cause covert shifts of attention even when they are uninformative. Nonetheless, it is still unclear to what extent oculomotor behaviour helps to explain manual response biases to social and non-social stimuli. Methods: In two experiments we tracked the gaze of 40 participants while performing two versions of the cueing task, which differed in task difficulty, with uninformative cues (gaze vs. arrow), SOA (250 vs. 750 ms) and cue validity (valid vs. invalid) as *within-subject* factors. Results: Experiment 1 confirmed previous behavioural findings and showed participants were faster when location cues were correctly directed towards the target. The analyses of initial saccades showed anticipatory movements in response to the cue which were larger in the longer compared to the short SOA condition, and faster in response to a gaze cue. Once the target appeared, the eyes fixated closer to the valid target location than to the invalid target location. In experiment 2 the task was more difficult and the arrow cue was associated with longer RTs and larger cueing-effect. However, the analysis of initial saccades showed similar eye movement patterns in response to both cues, which were solely affected by the SOA. After the target onset, landing positions of eye movements depended on the cued location, irrespective of validity. This work provides novel insight in the relation between attention and eye movements in response to social and non-social cues.

4 Studying Default Mode Network effective connectivity with a multimodal approach

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Background: The human brain is a network. At the large scale, its complex wiring diagram forms a network of hundreds of brain regions and thousands of interconnecting white matter axonal pathways. The brain function emerges from the topology of the network as a whole, the connectome of the brain. Analyses of resting-state functional magnetic resonance imaging (fMRI) data have demonstrated temporal correlations in the blood oxygen level-dependent (BOLD) signal of widely separated brain regions. These temporal correlations are presumed to reflect intrinsic functional connectivity as bases of communication within the network. Understanding the mechanisms that underlie communication between brain regions is one of the most intriguing and challenging questions. Methods: For increasing our knowledge about cortical connectivity at resting state I propose to investigate the functional connectivity of the default mode network (DMN) in healthy young subjects, using the combined navigated transcranial magnetic stimulation and electroencephalography (TMS-EEG) recordings. The recording sites will be defined by functional MRI analysis, and in the same time I will analyze neural sites with diffusion imaging and tractography methods. Results: When the networks will be defined from MRI data I will investigate the individual neurophysiological response based on data from resting-state intrinsic effective connectivity combining high-density EEG and TMS i.e., TMS-EEG. To evaluate cortico-cortical connectivity I will use the spatio-temporal distribution of TMS-evoked potentials (TEPs) and the oscillatory dynamics of the network based on time-frequency analysis.

5

Brain-wide mapping of intrinsic network dynamics in the mouse brain.

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Background: Resting-state functional magnetic resonance imaging (rsfMRI) has proven a powerful tool to investigate functional network activity via spontaneous fluctuations Blood-Oxygen-Level Dependent (BOLD) signal. Human rsfMRI research has shown that the resting brain exhibits a dynamic repertoire of brain network interactions between behaviorally relevant functional systems, which can be related to higher-order cognitive processes. Methods: By mapping the repertoire of spontaneous co-activation amongst brain regions, here we show that analogous recurrent spatio-temporal reconfigurations can be observed in rsfMRI readouts of the mouse brain. We used clustering analysis to sort and selectively average rsfMRI time frames into distinct and recurrent patterns of non-stationary co-activation and co-deactivation. We describe a reduced number of reproducible co-activation patterns (CAPs) encompassing co-occurrence of previously described intrinsic connectivity networks of the mouse brain, including integrative (default-mode, salience), as well as somato-motor and sub-cortical networks. Results: Notably, inverse co-occurrence of default-mode and lateral cortical networks activity was a prominent feature of many of the identified states, suggesting a competing relationship between these two macroscale neural systems and recapitulating a cardinal feature of human network organization. CAPs were also found to be characterized by smooth transitions between states, as well as gradual assembly and disassembly. Collectively, these findings suggest the presence of dynamic reconfiguration of spontaneous network activity as a fundamental evolutionary-conserved principle of the mammalian brain, and pave the way to targeted investigations of the neural drivers of these states via interventional approaches in rodent models.

6 Local network level integration mediates state-dependency during transcranial Alternating Current Stimulation

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Transcranial alternating current stimulation (tACS) has been proposed as a tool to draw causal inferences on the role of oscillatory activity in cognitive functioning and has the potential to induce long-term changes in cerebral networks. However, the mechanisms of action of tACS are not yet clear, though high variability and dependencies on brain and network state have been acknowledged. We used magnetoencephalography (MEG) to record brain activity from 17 healthy participants as they kept their eyes open (EO) or closed (EC) while being stimulated either with sham, weak, or strong alpha-tACS using a common montage targeting occipital areas. We reconstructed the activity of sources in all stimulation conditions by means of beamforming. Dependency of tACS on EC and EO states was assessed by computing statistics on a normalized contrast. The analysis of resting-state data showed that alpha enhancement driven by external stimulation interacted with the endogenous alpha level during EO and EC maximally in posterior cingulate, a region remote from areas showing strong alpha EC vs. EO modulation. This state-dependent effect was driven by oscillatory power and not by phase-alignment as could be assumed for tACS. Importantly, follow-up analysis of this online-tACS effect shows that it was mediated by the specific EC vs. EO connectivity modulation of precuneus in the no-tACS condition. This is the first evidence to illustrate how network modulations during different states influence tACS effects.

7 **Topography of the human acoustic radiation as revealed by *ex-vivo* fibers micro-dissection and *in-vivo* diffusion-based tractography.**

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Background: The acoustic radiation is a compact bundle of fibers conveying auditory information from the medial geniculate nucleus of the thalamus to the auditory cortex. Topographical knowledge of this bundle is scarce and *in-vivo* tractography reconstructions remain challenging. The AR represents a notable omission in the investigation of acoustic and linguistic functional mechanisms in humans. In this study we combine blunt micro-dissections and advanced diffusion tractography methods to provide novel insights into the topographical anatomy of this bundle in humans. Methods: **Dissections:** 4 human cerebral hemispheres were prepared according to a modified Klinger's technique. AR was approached posteriorly starting a layer-by-layer dissection from the posterior third of the superior temporal sulcus. **Tractography:** 4 subjects from the Human Connectome Project were analyzed in MrTrix3. The dataset is composed of 4 shells (10003000-5000-10000 s/mm²) at 1.25 mm isotropic resolution. A multi-tissue spherical deconvolution algorithm was fit to the data and anatomically-constrained probabilistic tractography was performed (0.75 mm step-size, 45° angle threshold, 1000 seeds/voxel). Results and Discussion: Both techniques show the unique transversal trajectory of the AR from the midline to the temporal lobe, and the intimate relationship of the AR with neighboring association and projection pathways. Probabilistic tractography and ultra-high b-values provided results comparable to blunt micro-dissections and highlighted the main limitations in tracking the AR. This is, to our knowledge, the first *ex vivo/in vivo* integrated study providing novel information about the anatomy of the AR, which will be important for future investigations in the neuroscientific, clinical and surgical field.

8 **How layer-dependent functional imaging influences current theories in cognitive neuroscience**

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9 **Featural similarity between concepts and recognition memory: the pupil's point of view**

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Differences in pupil dilation are observed for studied items compared to new ones in recognition memory tasks, known as the Pupil Old/New effect (PONE). Under cognitive load theory this effect is said to reflect greater cognitive demands of retrieving contextual information from the study phase. Pupil dilation can also occur when new items conceptually related to old items are erroneously recognized as old ("subjective" PONE), but the aspects of similarity that modulate false memory and related pupil responses remain unclear. We investigated this issue by manipulating the degree of featural similarity between new (unstudied) and old (studied) concepts in an old/new recognition task. Mass-univariate analysis on pupil data showed a subjective PONE, selective for new concepts with high featural similarity to old concepts. This result was corroborated by a principal components analysis showing differences between low-similarity new concepts, vs. old and high-similarity new concepts in two components related to recognition and decision-

function of the distractor's frequency, and was affected by the predictability of the distractor's position. While our results confirm that peripheral onsets can capture the eyes, they also reveal that such involuntary oculomotor response is subjected to a rapid habituation. In sum, likewise the covert attention system, the oculomotor system can exploit habituation mechanisms to reduce its responsiveness to visual distraction.

13 Effects of change in ambient luminance on retinal information coding

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It is well known that retinal ganglion cell response properties vary with changes in ambient light. However, the consequences of these changes for information processing in the retina are still largely unknown. Here, we investigated how retinal ganglion cell response type changes due to different ambient luminance levels are related to stimulus information carried by these cells. To quantify information carried by the ganglion cell responses, we first applied temporal non-negative matrix factorization to provided low-dimensional data-robust representations of spike trains that capture efficiently temporal information about sensory stimuli. We then decoded stimuli from this low-dimensional representation using multi class linear discriminant analysis and used cross-validated decoding performance to estimate mutual information between stimuli and spike trains. Confirming earlier studies, we found that a significant number of retinal ganglion cells changed their response type when the ambient light level changed from scotopic to mesopic. Our quantification of stimulus information showed that ganglion cells that kept their response type carried significantly more stimulus information than ganglion cells that changed their response type from scotopic to mesopic vision. Moreover, we found that ganglion cells that clearly behave as ON or OFF cells in at least one ambient light level carried significantly more information than cells without a clear type in any of the ambient light levels(Figure 1). Our results suggest that ambient luminance dependent response type changes cannot be attributed to efficient coding at the single-cell level but do not exclude the possibility that these type changes aid population codes.

14 Adjectives modulate motor activation elicited by nouns

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Recent studies have shown that both viewing graspable objects and understanding their names evoke manual motor programs. Some evidence has also suggested that this motor activation is inhibited or blocked when visual stimuli consist of dangerous visual objects or objects in which relevant features for action are violated. The aim of this study was to investigate whether this latter phenomenon appears when linguistic (instead of visual) stimuli are provided. Twenty healthy, right-handed participants were presented with pairs of words, each consisting of the name of a graspable object and an adjective giving disadvantageous (e.g. hot) or advantageous/neutral (e.g. reddish) information about the object's graspability. Participants had to categorize each object (indicated in the linguistic combinations) as natural or man-made, by performing either a precision or a power reach-to-grasp movement. Response grasps could be compatible or incompatible with the ones normally used to manipulate the objects denoted by the nouns. Results revealed that when the nouns were presented with anti-grasp adjectives, no difference in response time between compatible and incompatible conditions was found, indifferently for man-made and natural objects. In contrast, an action compatibility effect occurred when advantageous/neutral adjectives were combined with nouns referring to natural (but not man-made) objects. Our results suggest that the quality expressed by the adjective seems to be applied to the objects defined by the nouns, supporting an embodiment approach to language.

15 Cognitive neuroscience in the classroom: the current relationship between pedagogy and neuroscience

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There is a growing interest in basing educational decisions and practices on empiric evidence. Past studies have shown that teachers are keen to reap the benefits of neuroscience in order to ground their practice at school. Nevertheless, literature regarding these aspects in Italy is absent. A online survey was conducted with 207 Italian teachers working in Kindergarten (3-6 years), Primary School (6-11), Middle School (11-14), upper Secondary School (14-19). The purpose was to investigate the correlations between the goodness of the performance and: a) personal data b) explicit evaluations on neuroscience c) the influence of neuromyths. Questions investigated applied knowledge in general, linguistic and numerical cognition. As compared to the international studies, a contrastive method was used instead of a correlational one. Teachers showed high level of interest in neuroscientific contents but it did not correlated to the performance. However, neuromyths did not lure answers and gathered lower approval, as compared to the previous papers. Significant differences in the different levels of the sample did not emerged. Although neuromyths were not chosen too much, it emerged that many teachers asked for a higher training in neuroscience education, and this was confirmed by their implicit performance. This research turns out to be the first benchmark in Italy regarding the relationship between pedagogy and neuroscience.

16 Competence of mental numerical representation in Zebrafish (*Danio rerio*)

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Background: Although complex numerical skills are unique of our species, it is also true that a number sense is at the bottom of several representations present in other organisms. The main objective of my project is to study the numerical cognitive abilities in a comparative perspective in Zebrafish (*Danio rerio*). The experiments evaluate the discrimination of numerical quantities, the ordinal numerosity and the spatial numerical representations. Methods: Numerical abilities in fish are studied using behavioural paradigms that fit perfectly with the species used and the topic studied. One method consists in a spontaneous choice paradigm that make use of a spontaneous social preference by the zebrafish to join conspecifics as a shoaling behavior. This characteristic allow us to investigate magnitude discriminations in presence of different numbers of mates. A second procedure is based on an operant conditioning procedure. This paradigm is widely used in behavioral experiments when is required a particular behavior from the animal. For instance, we want to investigate if Zebrafish have ordinal numerical competence training the fish to identify and choose an object based on its ordinal numerical position in a series of identical objects (e.g. the second element in a series of 5 elements). Results: Results have confirmed the presence of rudimental numerical abilities in Zebrafish such as quantities discrimination and ordinal numerical abilities. Moreover, testing of zebrafish appears important because, given its widespread use in the field of genomics, it may provide a useful model organism linking research from behavior and genetics to the study of numerical representations.

17 Cortical effects of categorical learning for new words and multisensory objects

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Background: Thanks to the use of symbols such as words or numbers we organize our perceptual world into meaningful categories. However, the neural underpinnings of the emergence of categorical representations are largely unexplored. Methods: We designed a training experiment were participants learned for 9 days

to group eight new multisensory objects into four categories, basing on their size and on the pitch of an associated sound, and to refer to these categories with specific abstract names. By using fMRI, we recorded the patterns of brain activity evoked by the presentation of both multisensory objects and words before and after learning, while subjects performed different versions of a one-back task. Standard univariate procedures and Multivoxel Pattern Analysis (MVPa) will be used to investigate the cortical changes induced by symbolic categorical learning, and to describe whether these effects are task modulated. Results: Preliminary analysis conducted on 25 participants shows different effects on post-learning univariate cortical activation for our stimuli. In the case of multisensory objects, besides the same activity in visual and auditory cortices, we report stronger activation of the inferior portion of the Precuneus. In the case of words, we observe a dramatic increase of a left lateralized parieto-temporal network composed by the Angular Gyrus, Middle Temporal Gyrus, and Anterior Temporal Lobe. MVPa will be extensively used to describe whether and how the representational geometry of both objects and words change in these regions, as a function of learning or task.

18 Investigating Feature, Object, and Spatial Attention in Auditory Domain

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In everyday life human beings constantly segregate and integrate streams of sounds. This ability creates sounds objects that gives meaning to an otherwise cacophony of sounds. While in the visual domain many attentional mechanisms (e.g. attentive tracking) are very well established from many years of studies, in audition, remain to demonstrate and characterize the existence of similar or different mechanisms. We thus implement a series of psychophysical as well as neuroimaging (Magnetoencephalography) studies to test feature, object and spatial attention in the formation of a real-world coherent sound scape. We started from three psychophysical experiments. The first experiment's aim is to test the ability of the participants to follow a single trajectory of sounds created with binaural in ear individual recordings. In the second experiment using multiple trajectories, we want to test the ability to track multiple objects. In both experiments the listeners are cued beforehand, subsequently we present a "probe" with the ending part of the trajectory asking whether if it was coming from the trajectory itself or not. With a third experiment we want to test the ability to segregate between background and foreground sounds manipulating the feature space of this two dimension of natural auditory scenes. In all the three psychophysical experiments we expect to find a mediation of the attention in the performance of the listeners. The second phase of the project will focus on the neural mechanisms involved in these processes using magnetoencephalography. The aim of these studies is to sheds light on how auditory scenes are processed by the human beings.

19 Neocortical hubs and hierarchical control of resting-state fMRI network stability

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20 Music linking emotions

An Electrophysiological Study

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The aim of the present study was to investigate how auditory background can affect visual processing of faces. Reported effects of background music go toward both facilitatory ("Mozart effect") and interfering consequences, depending on the type of auditory stimulation and concurrent cognitive tasks. Relying on evidence of a preliminary study, here we designed a study using event related potentials (ERPs), in order to

investigate the neural mechanism of memory encoding for faces during listening to classical music (Čajkovskij), environmental sounds (rain) or silence. Participants were 15 healthy non-musician university students, engaged in an old/new memory task (involving the study of about 400 unknown faces, followed by a recognition phase). Results indicate that listening to music enhances memory recollection of faces. Listening to music led to a better encoding of the visual stimulus (as compared to listening to rain), as indexed by an increased Anterior Negativity. The FN400 prefrontal response recorded during the memory task showed a gradient in its amplitude reflecting face familiarity (with smaller negativities to faces associated with music and larger FN400 to new faces). A swLORETA analysis showed the main involvement of Superior Temporal Gyrus (STG) and medial frontal gyrus in the integration of audio-visual information. This data show how listening to touching music enhances memory for faces, probably because of the music emotional content, which, in association with face visual characteristic, makes the memory engram more solid.

21 **How evidential impact affects perceptual probabilistic reasoning**

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Background: Our studies aimed to explore how people judge the posterior probability of a hypothesis $Pr(h|e)$ in inductive inferences with perceptual material. Evidence from previous works with different types of stimuli suggested that confirmation relations might predict probability judgments with abstract or linguistic content better than posterior probability: Is this also true for arguments with a perceptual content? If this were true, we would expect people to overestimate probability when confirmation and probability relations suggest similar predictions and underestimate it when confirmation and probability relations suggest opposite predictions. Methods: We ran four computer-based studies to test our hypothesis. In these experiments, we manipulated posteriors and evidential impact to see whether and how they interacted in affecting probability judgments. After looking at sets of figures with different shapes and colors, participants were presented just the shape of one of these figures (i.e., the *evidence*) and were asked to guess its color (i.e., the *hypothesis*) or vice versa. Results: When participants had to guess the color of a figure given its shape, their judgments were not affected by impact relations. On the contrary, when they had to guess the shape of a figure in light of its color, participants tended to overestimate the probability of the hypothesis if impact was positive, and underestimate it if impact was negative. Possible explanations for the phenomenon are discussed.

22 **Neurofunctional correlates of object and action naming practice in healthy controls**

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23 **Naive chicks social preferences for objects aligning with their motion direction**

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Elementary features of the motion of a single 2D shape moving on a homogeneous background elicit the perception of animacy in adult observers. Among these features is the alignment of the object main axis with the direction of motion: objects that maintain their axis consistently aligned with the direction of motion are perceived as being “more animate”. This is likely to derive from the fact that in most bilateria

the direction of travel is constrained by the orientation of the anteroposterior axis, making this a reliable cue of animacy. Moreover, 6-month-old infants spontaneously encode the orientation of agents' anteroposterior axis, suggesting an early mechanism for attending to this cue. We employed an animal model to study the evolutionary and developmental origins of these phenomena. In two experiments we tested dark-hatched visually naive chicks for their spontaneous approach preferences between two stimuli. Each stimulus was a video-animation of a red cylinder moving on a black background. The object entered the screen already in motion appearing from its upper left corner and moving downward along the diagonal; when it reached the midline of the screen the object's trajectory made a 90° turn. Chicks showed a significant preference for objects that: i) maintained their main axis aligned with motion direction after turning (realigning with the new trajectory); ii) that moved along their main axis rather than orthogonally to it and/or that maintained a stable axial direction (with the same of its' two extremities always facing forward).

24 Spatio-temporal subcomponents of Episodic Memory in Williams Syndrome

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Williams Syndrome (WS) is a rare neurodevelopmental disorder characterised by a number of medical problems as well as mental delay, hypersociability, and visuospatial impairments. The condition is caused by gene deletion on chromosome 7q11.23, which in turn prevents the synthesis of specific proteins needed for the normal functional development of the hippocampal formation. Recent neuroimaging studies have produced evidence that the hippocampus is involved in the retrieval of associations between events and their spatial contexts. Given the hippocampal functional impairment that affects WS individuals, the present study set out to investigate spatial binding abilities in this population by evaluating their performance on an episodic memory hiding task and comparing it to typically developing chronological and mental age matched controls. Overall, episodic memory retrieval was delayed in WS participants when performance was compared with mental and chronological age controls ($F_{(1,17)} = 5,15$ $p = ,037$). More importantly, WS participants were found to be selectively impaired in their ability to retrieve the spatio-temporal information associated with the distinct pattern of hiding they had previously encoded, as compared to the two control groups ($F_{(2,34)} = 5,57$ $p = ,008$). The resulting impaired memory profile is consistent with hippocampal anomalies documented in Williams Syndrome, and further supports a specific role of the hippocampus in the binding together and subsequent retrieval of the spatio-temporal subcomponents of episodic memory.

25 On the Importance of Psychologically Plausible Approaches to Cognitive Neuroscience

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A point that has been emphasized in cognitive neuroscience is that analytic techniques ought to be biologically plausible in the sense that they rest on principles similar to those that govern how the brain represents and processes information. In particular, a chief virtue of multivariate pattern analysis (MVPA) techniques is supposed to be their biological plausibility. We suggest that of equal importance is that analytic techniques also be "psychologically plausible", in the sense that they rest on principles of how our psychology drives behavior. We focus on one particular family of psychologically plausible approaches: those that use models of categorization from cognitive psychology that depend on distance functions specified for a psychological space. These distance function-based models can be related to neural activation spaces measured using MVPA in order to predict observer behavior, as we illustrate by reviewing some of our experimental work that has made use of these models. We also point to challenges raised by trying to directly related these distance function-based models to patterns of neural responses.

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Second language performance in children with poor literacy skills

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Recent studies indicate that children with poor literacy skills in their first language perform significantly below control participants in second language learning. However, it remains unclear to what extent these findings apply to individual students, as most studies only report group-averages. Furthermore, it is not clear if difficulties are limited to written, or also extend to spoken second language tasks. In the present study we assessed the spoken and written second language skills of a group of 11-12 year old German-speaking children with and without poor literacy skills ($n = 64$) that received English as a second language instruction for a period of 3 years. All children completed the following second language tasks: nonword discrimination, nonword repetition, spoken word picture matching, picture naming, word and nonword reading and spelling. As a group, children with poor literacy skills scored below the control group on second language literacy, spoken word comprehension and production, but not on nonword discrimination and production tasks. Importantly, however, not a single child's performance actually mirrored the average scores. Also, at an individual level more than half of the children with poor literacy skills (59%) performed at the same level as the control group on all second language measures. These findings indicate considerable variability with many children with poor literacy skills being just as successful as their peers with average literacy skills in learning a second language.

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Determining what information is transmitted across neural populations

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Quantifying the amount of information communicated between neural population is crucial to understand brain dynamics. To address these question, many tools for the analysis of time series of neural activity, such as Granger causality, Transfer Entropy, Directed Information have been proposed. However, none of these popular model free measures can reveal what information has been exchanged. Therefore, we developed a new measure, exploiting benefits of novel Partial Information Decomposition framework, that determines how much information about each specific stimulus or task feature has been transferred between two neuronal populations. We tested this methodology on simulated neural data and showed that that it captures the specific information being transmitted very well, and it is also highly robust to several of the confounds that have proven to be problematic for previous methods. Moreover, the measure was significantly better in detection of the temporal evolution of the information transfer and the directionality of it than the previous measures. We also applied the measure to an EEG dataset acquired during a face detection task that revealed interesting patterns of interhemispheric phase-specific information transfer. We finally analyzed high gamma activity in an MEG dataset of a visuomotor associations. Our measure allowed for tracing of the stimulus information flow and it confirmed the notion that dorsal fronto-parietal network is crucial for the visuomotor computations transforming visual information into motor plans. Altogether our work suggests that our new measure has potential to uncover previously hidden specific information transfer dynamics in neural communication.

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Information search patterns disclose representation-building in complex cognition

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Background: In problem-solving and decision-making, agents need to form an efficient representation of the current relational environment in order to make efficient choices. However, few studies successfully characterized the intentional process of representation-building and its respective cognitive underpinnings, that have been constantly confounded with mechanisms related to maintenance and updating of information. In the present study, we developed a novel approach to disclose the dynamic process of representation-construction based on patterns of information search in a relational reasoning task. Methods: We recorded eye movements of 50 participants while performing a novel task designed to isolate the process of construction of relational representations. First, we tracked the dynamic evolution of specific attentional features to identify early endogenous information-search phases in each subject. We then used eye-data to extract patterns of information acquisition that expressed different strategies in representing relational information. Results: We individuated two representation-building strategies: integrated and disjointed. Participants building integrated representations searched for existent relational information to grasp the full complexity of the environment, while participants constructing disjointed representations encoded pieces of information in isolation without relational integration. The former cluster of participants showed markedly higher performance than the latter in the reasoning task and exhibited a superior cognitive reflection level. Interestingly, the two groups did not differ in any measures of fluid intelligence and working memory, suggesting that these two latter functions sustain maintenance and updating mechanisms without intervening in the representation building process. The current results highlight how our method can shed light on a crucial aspect of higher cognition such as representation-building, questioning the central role historically assigned to intelligence and working memory in explaining how human beings understand and represent complex environments.

29 **Working for water without thirst: a human Pavlovian-instrumental transfer study.**

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In the phenomenon known as Pavlovian-Instrumental transfer (PIT), a Pavlovian conditioned stimulus (CS) is able to strengthen an instrumental action exerted to obtain an outcome. Such ability reflects the incentive-motivational salience acquired by the CS. The present study addressed whether the CS motivational properties vary dynamically with the value of the associated outcome, by adopting a PIT paradigm and outcome devaluation. Previous studies have shown that in some cases post-training devaluation leaves PIT unaffected when outcomes are palatable foods or drugs, and when the devalued outcome is not consumed immediately. In Experiment 1, thirsty participants first learned to squeeze a rubber bulb to accumulate a beverage (plain water or sugary drink); then participants learned Pavlovian associations between cues and the beverage. When tested in extinction, a PIT effect emerged as expected. In Experiment 2, instead, the PIT effect emerged despite participants quenched their thirst, thus changing their physiological state, before undergoing the test phase. Our results suggest that the incentive properties of a CS can surprisingly and irrationally endure the devaluation of the associated outcome even when plain water is used as reward, and thirst is quenched by immediate reward consumption. This result may provide important insights in the understanding of the psychological mechanisms underlying different types of addiction.

FRIDAY- SESSION B (15:30-16:30)

1 ERP correlates of syntactic processing in cochlear implant users: A preliminary report

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Background: Studies on linguistic abilities of cochlear implant (CI) users revealed issues in complex syntactic structures rather than lexical, semantic and phonological knowledge (for studies in Italian see Guasti et al., 2012; Caselli et al., 2012). Previous studies on hearing monolinguals and bilinguals showed that ERPs are sensitive to differences in processing of syntactic relationship (e.g., Tanner & Van Hell, 2014) even when language proficiency is comparable. The purpose of our experiment is to use real-time and behavioral measures to evaluate how the CI impacts on language. Methods: To this aim we tested CI users and age-matched hearing controls with a rapid visual word-by-word sentence presentation while recording the EEG signal. Participants were presented with 320 sentences, half of them containing either a syntactic agreement (subject-verb) or a semantic violation. Results: Both CI users and NH controls showed N400 and P600 in response to semantic and syntactic violations respectively. Despite our small and non-homogenous CI group, CI users showed a different pattern in the early stage of detection of syntactic violations. While NH controls showed a LAN, CI users showed a larger P2 in an earlier time window (180-220 ms) at left-frontal sites ((DFn=2, DFd=80), F=3.601, p=0.003). P2 has been linked to attention-related processes (Luck & Hillyard, 1994) and its amplitude may reflect an enhanced processing at an orthographic level. These results may provide initial indications that CI users pay more attention on upcoming morphological features of words.

2 Acting differently: what happens when we observe a dissimilar attitude towards others?

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Background: In Economics and Psychology, social preference is defined as the general attitude that people display towards others. This attitude may be characterised by a sense of fairness, generosity, but also competitiveness or spite. A number of theories consider social preferences to be a stable trait, and experimental evidence suggests that they are indeed a good predictor of behaviour in various contexts. In the current work, We will present an alternative explanation to the stability of social preferences; namely, that people tend to interpret different situations as underlain by similar social rules of conduct. To test this hypothesis, We explore whether observing a different conduct makes people's preferences shift towards the observed behaviour. Methods: We measure social preferences using an allocation task where participants have to decide how to distribute different amounts of money between them and another, unknown person. Answers and response times are combined in a sequential sampling model (SSM) to obtain an estimate of their preferences. The task is presented twice, before and after observing and learning how a group of people has decided in the same task. With the help of computational analyses, We quantify in what way and to what extent observation shapes not only behaviour but also its underlying cognitive processes. The same task is repeated using functional magnetic resonance imaging (fMRI) to identify areas in the brain related to observation. Results: We present simulations showing how the hypothesised mechanism should work and, if applicable, preliminary findings on the behaviour of participants in the allocation task.

3 Eat Pray Love. Processing of concrete and abstract verbs by native and non-native speakers

Katharina Kühne¹, Claudia Gianelli¹

1. University of Potsdam

The amodal system theory of language suggests that cognition is built of abstract representations via formal rules, while the “embodied” approach claims the role of neural sensorimotor systems in language processing. Debating theories have so far focused mostly on concrete concepts, while evidence on abstracts concepts is still limited. Strikingly, most of this evidence was collected on native speakers, thus leaving open the question as to whether and how second-language processing is comparable to first-language “embodiment”. In the present study we aimed to investigate detailed concrete and abstract verb processing in two groups of speakers: one composed of German native speakers (L1 group), the other of native speakers of Russian with very good German knowledge (not bilinguals, L2 group). Both groups were tested on a passive reading task (with German hand-, foot-, mouth-related, and abstract stimuli) while continuous EEG (64 channels) was recorded. Data analyses focused on event-related desynchronization (8-13 and 15-20 Hz) as a measure of sensorimotor processing, hypothesizing a different modulation of cortical oscillations in the two bands depending on verb type (concrete vs. abstract) and group (L1 vs. L2). Preliminary data analyses confirm a different modulation of these measures in terms of concrete-abstract verb processing (both in L1 and in L2), as well as with respect to the language group (magnitude of the effect in L1 and L2). Interestingly, results from our sample also suggest a possible correlation between the age of L2 acquisition and the embodiment of both abstract and concrete language.

4 Neural correlates of distorted body representations underlying tactile distance perception

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Tactile distance perception is believed to require that immediate afferent signals be referenced to a stored representation of body size and shape (the body model). For this ability, recent studies have reported that the stored body representations involved are highly distorted, at least in the case of the hand, with the hand dorsum represented as wider and squatter than it actually is. Here, we aim to define the neural basis of this phenomenon. In a behavioural experiment participants estimated the distance between touches on two points by adjusting the length of a visually-presented line on the screen. The technique of multidimensional scaling (MDS) was used to reconstruct a perceptual map of tactile space. Analysis of spatial distortion using Procrustes alignment showed that maps were stretched in the mediolateral hand axis. In order to determine the neural correlates of these body distortions, we performed a functional magnetic imaging (fMRI) study in which we delivered on the dorsum of the right hand of each participant nine tactile stimuli organized as a 3x3 square grid. We used a searchlight approach within pre-defined regions of interests (ROIs) to compute the pairwise Euclidean distances between the neural patterns associated with the tactile stimulations and we then compared the neural dissimilarity matrices to models representing different shapes. We were able to reconstruct the perceptual map of tactile space in the contralateral primary somatosensory and motor cortices. This suggests that these areas are critical to generate the tactile representations of the dorsum of the hand.

5 Use of fNIRS to study functional connectivity in the newborn brain: a source-space data analysis approach

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Background: The organization of functional connectivity in the adult brain has been extensively explored. The study of the inception and development of functional connectivity in the newborn brain, on the other hand, remains a challenge. To this end, Functional Near Infrared Spectroscopy (fNIRS) represents a promising technique to investigate cortical activity and connectivity during early development. However, the lack of anatomical reference and of standard procedure for the arrangement of source and detectors onto the scalp are critical drawbacks of the technique.

Methods: Typically, fNIRS signals collected by the sensors distributed on the scalp are analyzed directly, resulting in coarse-grained distribution of activity in the sensor space. In this study, we developed a tool to reconstruct patterns of spatially distributed functional signals on an anatomical template (source space).

This method enables assessment of the anatomical location of fNIRS signals, and provides a means to optimize probe design for the investigation of specific anatomical districts. We validated our tool for preterm and term newborns using a 4D dedicated atlas. Synthetic correlation patterns were generated simulating light propagation in brain tissues. We simulated signals with different noise levels to test the accuracy of reconstruction under realistic SNR conditions, and to assess different probe geometries.

Results: This work aims to investigate the applicability of fNIRS to functional connectivity studies in infants. Evaluation of sources localization accuracy confirms the goodness of the method to reconstruct reliable spatial patterns. Moreover, the tool represents a powerful means for probe design and provides a first step towards a source space connectivity analysis of real newborn's data.

6 Mapping functional interactions between the ventral stream and the fronto-parietal motor network during a pantomime task.

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1. *CIMEC, University of Trento*

Pantomimes of tool actions engage regions within the fronto-parietal motor network, such as the supra-marginal gyrus (SMG) and the ventral premotor cortex (PMv), and the ventral stream, such as the middle-temporal gyrus (MTG). Similar action-related processing has been shown in both networks suggesting a possible interaction between them. Nevertheless, their specific functional role remains unclear. We conducted an fMRI study to define differences and similarities in action encoding within the two networks and the functional interactions between them. We adopted a 2x2 factorial design together with a delayed execution task, which allows dissociating planning and execution phase of an action. Participants planned and pantomimed a "grasp-to-move" or a "grasp-to-use" action (factor: "action goal"), either with a pair of scissors or an axe (factor: "tool"). ROI-based MVPA approach was conducted to investigate if "concrete" action information (move vs use with a specific tool) and "abstract" goal information (move vs use across tools) are represented within the considered ROIs (MTG, SMG, PMV).

MVPA showed significant encoding for "concrete" action information in all ROIs during the planning and execution phases of the task. "Abstract" goal encoding was significant within MTG during both phases, whereas in SMG and PMv only during execution. Connectivity analysis supported the exchange of information from MTG to SMG and PMV during execution. Our results showed that "abstract" goal information is encoded earlier in the ventral stream and later transferred to the fronto-parietal network, supporting a differential encoding within these streams and their functional interaction during pantomime of tool actions.

7 Effects of ketamine on the modular organization of brain functional connectivity in healthy volunteers: a model of psychosis

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Ketamine, a psychoactive compound, has been found to mimic positive, negative, and cognitive schizophrenia symptoms, when taken at a sub-anesthetic level. From this observation, intravenous injections of the drug in healthy volunteers have been recently exploited as a model for psychosis. Through the application of graph theoretical modular approaches, we seek to evaluate altered functional integration and segregation between brain regions following a ketamine challenge. Addressing modular changes after intake of a psychoactive compound, we aim to provide new insights over functional connectivity reorganization during psychosis, and possibly explain the occurrence of cognitive dysfunctions, similarly to what we recently observed in schizophrenia. Sixteen participants completed the study, undergoing resting state functional magnetic resonance imaging (rsfMRI). Before image acquisition, each participant received an oral dose of placebo. Later, after 5 minutes of scanning, an intravenous injection of ketamine, at a sub-anesthetic dose, was administered. Next, the brain will be parcellated into 638 regions, and connectivity matrices will be generated by correlating functional connectivity of all areas. Modular organization will be investigated before and after ketamine injection, addressing the impact of the psychoactive drug over functional connectivity. Here, we expect to detect a modular fragmentation, after ketamine injection,

involving mostly primary sensory cortices. We recently observed reorganization of such regions in schizophrenia, suggesting a central role of primary sensory alterations. Starting with a replication of this phenomenon would further confirm the validity of ketamine as a model for schizophrenia, besides unravelling functional connectivity reorganizations induced by this psychoactive drug.

8 Role of Posterior Intraparietal Sulcus in the Comprehension of Reversibility

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Background: Many studies have focused on the heuristics involved in the comprehension of reversible sentences. However, relatively little is known of the neural underpinnings of these processes. Recent lesion studies (Thothathiri et al, 2012) and TMS investigations (Finocchiaro et al, 2015; forthcoming) pointed to an involvement of the left temporoparietal regions. For example, Finocchiaro et al (2015) found that TMS to the posterior intraparietal sulcus (pIPS) facilitated processing of passive reversible sentences. However, these studies investigated the comprehension of reversible sentences by focusing only on active and passive declaratives. Therefore, it is not clear whether pIPS is relevant for processing the grammatical features of reversible sentences (eg, the –by phrase in passives) or reversibility per se. To understand the role of pIPS in sentence comprehension, two types of reversible sentences will be used in this study: active and passive declaratives, and majority and minority comparatives.

Methods: This study will consider performance on reversible declarative sentences in the active voice (DA; The girl kisses the boy), and in passive voice (DP; The boy is kissed by the girl), and on comparative sentences of majority (MaC; The girl is more freckled than the boy) and minority (MiC; The boy is less freckled than the girl). The task will be administered in Italian, to native Italian speakers. In a timed sentence-picture verification task, participants will be presented with a sentence and a picture simultaneously, and will be asked to verify if sentence and picture match. Responses will be recorded using a button-press. Participants will receive three trains of biphasic pulses to the left pIPS at 5 Hz at intervals of 200ms from stimulus onset. Each subject will complete the task under a real-TMS and a sham-TMS condition. Sessions will be administered in counterbalanced order across participants.

Expected Results: If the pIPS is involved in the comprehension of reversibility itself, then its stimulation will facilitate the comprehension of the more complex reversible sentences, regardless of whether they are of the declarative or the comparative type. If the pIPS is critical for processing the syntactic properties of reversible sentences, pIPS stimulation will facilitate only the comprehension of DP sentences, and performance on DA, MaC and MiC sentences will be unaffected.

9 Reconsolidation as a window of opportunity to strengthen existing episodic memories in older adults with subjective memory complaints.

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Some important domains of cognitive ability decline with age, including processing speed, memory, reasoning and language. Subjective memory complaints (SMC) are defined by self reports of memory worsening and objective memory performance in the normal range. SMC are commonly reported by elderly adults with a prevalence estimated from 22% to 56% of this population. The concept of SMC is highly significant to the field of aging because this condition is a risk factor for developing dementia. The potential and possibilities for prevention of cognitive disorders in older adults have increased substantially in recent years. Previous studies have shown that transcranial Direct Current Stimulation (tDCS) over the left prefrontal cortex (PFC) strengthened existing verbal episodic memories, conceivably through

reconsolidation, in healthy older adults. The aim of this randomized, double-blind, placebo-controlled study was to test the hypothesis that tDCS with the anode over the left lateral PFC would strengthen existing episodic memories in older adults with subjective memory complaints. On Day 1, subjects learned a list of words. 24h later, tDCS (anodal or placebo) was applied after a contextual reminder. Memory retrieval was tested 48h and 1 month later. Anodal tDCS over the lateral PFC strengthened existing episodic memories, an effect indicated by enhanced recognition performance up to 30 days, relative to placebo stimulation. These findings open up the possibility to design specific interventions aimed at preventing memory decline in this at-risk population.

10 “Is it funny?” or “Is it strange?” Investigating humor through cognitive psychology

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Humor is a multifaceted function unique to human beings, like language and symbolic thought. Theories of humor propose different frameworks to investigate this function empirically; here, we applied a cognitive-psychology approach, focusing on a specific humor task. We asked 32 participants to listen to 30 jokes intermixed with 30 non-jokes that had an implausible ending, and to decide whether or not each stimulus was funny (Humor Decision Task, HDT). In a control task, 30 plausible stories were intermixed with 30 stories with an implausible ending and participants had to decide whether or not each stimulus was “strange” (Implausibility Decision Task, IDT). Response times (RT) in correct responses indicated that the two tasks involved different cognitive operations: while “yes, funny” responses were 256 ms faster than “no, not-funny” responses, “yes, strange” responses took the same time as “no, not-strange” ones. IDT results could be explained by assuming that participants used the degree of semantic overlap between the setup and the ending of the story to select a response. Two different cognitive accounts for the HDT results are offered, the “recognition” and the “sequential attempts” model. According to the “recognition” account, participants activate long-term memory (LTM) abstract representations of the semantic structure of jokes, while the “sequential attempts” account implies a trial-and-error strategy to find a solution to the puzzle posed by a punchline that is not already available in LTM. The RT pattern observed in incorrect responses led us to reject the “recognition” account and support the “sequential attempts” hypothesis.

11 Decoding auditory motion direction and location in hMT+/v5 and Planum Temporale of sighted and blind individuals

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In sighted individuals, a region of the middle occipito-temporal cortex (MT) specializes for the coding of visual motion whereas the planum temporale (PT) responds preferentially to auditory motion. In case of early visual deprivation, MT region enhance its response tuning toward moving sounds. Whether MT contains directional tuning in the blind, as well as the impact of such functional reorganization on PT region remains however poorly understood. In our study, we used fMRI to characterize the brain activity of sighted and early blind individuals listening to left, right, up and down moving as well as static sounds. Whole brain univariate results revealed that, in addition to a dorsal fronto-temporo-parietal network including PT, preferential response to auditory motion was observed in the anterior portion of MT in both groups. In contrast, more posterior part of MT showed stronger auditory motion selectivity in the blind. While we were able to significantly decode auditory motion direction in PT and MT in both groups, classification accuracies in the blind were significantly higher in MT and lower in PT when compared to the sighted. Moreover, sound location could only be reliably decoded in MT bilaterally in the blind, while the left PT contained more location information in the sighted. Altogether, our results demonstrate that early visual deprivation triggers enhanced tuning for auditory motion direction and location in MT regions; co-occurring with a reduced computational involvement of PT region. These results shed important new lights on how sensory deprivation triggers a complex interplay between the reorganized and the typical regions supporting a specific process.

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The neural correlates of visual mental imagery

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Visual imagery (VI) activates a widespread network of brain areas, comprising parietal, temporal and frontal regions, and early visual cortex (EVC). Whereas previous studies used a wide variety of stimuli, it is currently not known which stimulus categories lead to the most reliable recruitment of EVC during imagery. In Exp. 1, we examined which categories lead to a stable eccentricity effect (i.e. increasing reaction times with increasing stimulus eccentricity) when imagined. We asked participants to imagine six different stimulus categories at four locations. An auditory cue indicated where to imagine the stimulus. Participants pressed a button when they reached a vivid imagery; reaction times (RTs) and eye movements were recorded. In Exp. 2, we used fMRI to determine which stimulus category leads to the most reliable recruitment of EVC. Participants were asked to centrally imagine different stimuli pertaining to a subset of the categories used in Exp. 1 (lowercase letters, objects and simple shapes). After a delay, a dot appeared and participants had to judge whether or not it fell on the imagined stimulus.

Exp. 1 revealed a robust eccentricity effect for all six stimulus categories. In Exp. 2, we found that VI of all stimulus categories recruited EVC. Using multiclass MVPA, we were able to distinguish between imagined stimulus categories in EVC. Our results suggest that all six examined stimulus categories are potentially suitable to recruit EVC. Exp. 2 confirmed these results and revealed that VI of different stimulus categories leads to different patterns of activation in EVC.

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Defining spatial boundaries: a developmental study

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While navigation by environmental boundaries has been widely documented across various species, the factors that define a surface as a boundary have yet to be determined. What is the fundamental difference between an array of objects and an array of walls? Previous work has shown that young children succeed in using boundary-surfaces as long as they are 3D and extended on the ground-plane, while they fail to use geometric arrays made up of free-standing objects. However, it is still not clear whether the use of boundaries in navigation relates to their capacity of preventing movement and what is the point at which an object is long enough to be represented as a boundary.

We tested children's 4 to 9 years old reorientation capacity with discontinuous boundaries made up of 20 closely-aligned objects with an inter-object space of either 16cm, 8cm (exp.1-exp.2), or compactly arranged as to form either four distinct 50cm walls (exp.3) or two long 100cm walls (exp.4). Our results suggest children develop the capacity of using discontinuous boundaries around the 7th year of age, even if the configuration is sufficiently dense to underline the geometric structure and to prevent movement. This argues for a late-emerging capacity of extrapolating boundary information from discontinuous structures. Furthermore, preliminary data in experiments 3 and 4 show that younger children are not able to use 50cm walls but perform well with two 100cm walls, suggesting there might be a specific wall-length at which children start perceiving

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Effects of attention on visual processing between cortical layers and cortical areas

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Background: Attention is critical to high level cognition and it improves perceptual abilities. Many studies have delineated how attention affects neuronal firing rates, rate variability, and neuronal correlations, but a detailed understanding of how this differs between cortical layers and different cell types is still not clear. Current research interest is focused on the way neural information is exchanged among different neural populations within and between cortical regions.

Methods: Electrophysiological recordings performed in Newcastle, by using multi-contact silicone probes, allowed to access neural activity of macaque V1 and V4 while performing cued spatial attention task. The signal analysis went through the extraction of Local Field Potentials (LFPs) and Envelope Multi-Unit Activities (MUAEs), to address the main issue of aligning laminar depths across experimental sessions. Reference alignment point was chosen to fall within the granular layer (for both V1 and V4), the location of earliest input current. Next stages of analysis consisted in trial-averaging, then computing the Current Source Densities (CSDs) and Latency indexes. The selection of the earliest significant sink locations were performed manually with the support of a Matlab® Graphical User Interface developed for the specific purpose. Lastly, all of the above electrophysiological measures (LFPs, MUAEs, CSDs, Latency indexes) were averaged across experimental sessions. Results: The main results achieved by now consist of the laminar depth alignment distances for each session, and the average laminar profiles of the two cortical regions (V1, V4). This will allow to access the single-unit activity to test hypotheses about the information processing at cellular level.

15 **Allocentric representation: a different approach to acoustic space learning**

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Perception of acoustic space is a fundamental and remarkable feature of human auditory system. Several studies so far showed that human brain can adapt to conditions of partial hearing impairment, learning to map altered auditory localisation cues to spatial coordinates in external space. Different behavioural training paradigms have been proposed to promote acoustic space learning. Those trainings mainly adopted an egocentric representation of sounds. In the present study, we aim to investigate the impact of two types of multisensory (Audio-Visual) training, focused on egocentric and allocentric representation respectively, on sound localisation learning. We implemented an experimental protocol of five consecutive days, comprising testing of free-field sound localisation and training sessions. Participants were tested in monaural hearing condition (left ear plugged), in order to alter auditory localisation cues. Distinct groups of participants underwent two different Audio-Visual training paradigms: 1) localisation of a target sound between three consecutive sounds (egocentric representation); 2) auditory spatial bisection task, in which participants have to judge spatial relations between three consecutive sounds (allocentric representation). A third group (control) took part only in testing sessions of single sound localisation, without performing any training procedure. First of all, we expect to observe learning effects in training groups compared to control group. Moreover, we predict different effectiveness degrees of the distinct training procedures in promoting single sound localisation. Results will allow us to further clarify the link between egocentric and allocentric representation of acoustic space.

16 **Cortical representations of semantic information generalise across sensory-based and abstract knowledge referred to food**

Danilo Rubicondo¹, Scott Fairhall¹

1. *CIMeC, University of Trento*

Knowledge about an object may be stored in the brain as the set of object sensory-functional properties. However, it is not clear how this principle extends to abstract knowledge, which is sensory-functionally undefined. Knowledge about food is valuable in disentangling this issue, since food is associated with the sensory dimension of taste, but also with a wealth of abstract information. Does the neural representation of knowledge about food change depending on the sensory or abstract base? We investigated how the brain represents food-knowledge about taste and conceptual taste-unrelated information (i.e. food origin). We presented subjects with words depicting traditional Italian dishes (along with control words), while recording BOLD signal. In three tasks we manipulated the type of knowledge and the cognitive load, so that participants expressed judgments about dishes taste (task 1), retrieved dishes geographical provenance (task 2) and matched dishes for origin (task 3). A cross-task searchlight classification individuated a general representation of food knowledge in a portion of the left insula, anatomically consistent with the gustatory

cortex. This representation is persistent across taste and taste-unrelated information, regardless different executive processes. Notably, such food representation cannot be attributed to visual properties of the stimuli, because symbolic cues (i.e. words) were used. This result shows that - at least in the case of food - abstract and sensory information share a common basis. Abstract and sensory-based knowledge appear to vary along a continuum of sensorial content, while be constrained by the same organizational principles.

17 Thermal referral: evidence for a thermoceptive uniformity illusion without touch

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When warm thermal stimulators are placed on the ring and index fingers of one hand, and a neutral-temperature stimulator on the middle finger, all three fingers feel warm. This illusion is known as thermal referral (TR). On one interpretation, the heterogeneous thermal signals are overridden by homogenous tactile signals. This cross-modal thermo-tactile interaction could reflect a process of object recognition, based on the prior that many objects are thermally homogenous. Interestingly, the illusion was reported to disappear when the middle digit was lifted off the thermal stimulator, suggesting that tactile stimulation is necessary. However, no study has investigated whether purely thermal stimulation might induce TR, without any tactile object to which temperature can be attributed. We used radiant thermal stimulation to deliver purely thermal stimuli, which either were or were not accompanied by simultaneous touch. We found identical TR effects in both the original thermo-tactile condition, and in a purely thermoceptive condition where no tactile object was present. Control experiments ruled out explanations based on poor spatial discrimination of warm signals. Our purely thermoceptive results suggest that TR could reflect low-level organization of the thermoceptive pathway, rather than a cognitive intermodal modulation based on tactile object perception.

18 Priming Regret: Induced counterfactual thinking drives learning strategy in a novel task

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Background: In counterfactual learning, the brain compares actual outcomes of choices to the outcomes of choices not made. When these alternative outcomes are knowable, the comparison can induce regret or relief. These emotions, which rely on imagining an alternative reality, can guide learning within the same task. But can this learning mechanism transfer from one decision context to another? Methods: Subjects are primed with partial or complete feedback in a wheel of fortune choice task, then play an unrelated competitive strategy card game. Using a hybrid learning model called experience-weighted attraction, we analyze at what ratio subjects employ two types of strategic learning. Results: Preliminary results show some inconsistent differentiation of outcomes among groups. We anticipate modeling will show that those primed with a negative outcome in complete feedback (i.e. counterfactual priming) exhibit greater tendencies to employ belief-based learning strategies in the card game – versus reinforcement learning strategies – whereas those primed with positive or partial feedback, and those with no priming, exhibit a lower ratio of belief-based to reinforcement learning.

19 A complete pre-processing pipeline for calcium imaging data

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Background: Two-photon calcium imaging allows monitoring the population activity of hundreds of neurons in superficial and deep brain regions of awake mice. Calcium imaging has a high spatial resolution, which

makes it possible to disentangle signals coming from neighbouring and overlapping neurons. On the other hand, it has a limited temporal resolution and demands a complex pre-processing pipeline. A careful assessment of the settings for data acquisition and of the pre-processing pipeline is therefore fundamental in order to optimize the quality of the extracted neural signals. Methods: We applied state-of-the-art algorithms to both experimental and realistic calcium imaging data in order to assess their performance and define an optimized pre-processing pipeline. We first corrected motion artefacts using non-rigid deformations of the imaging frames. Then, we used non-negative matrix factorization to identify cells and extract calcium signals. Lastly, we inferred spiking activity from the calcium time signals. Results: We applied the pre-processing pipeline to data collected in different brain regions of anesthetized and awake mice. Automated algorithms for motion correction and cells detection yielded good performances, giving results qualitatively similar to expert manual processing. We then systematically explored the effect of increasing the temporal resolution, at cost of spatial resolution. A gain in the temporal resolution from 1 Hz to 4.5 Hz could be obtained without significant deterioration of the cells detection. For higher sampling rate, instead, the segmentation was not effective and neural signals could not be efficiently extracted from the data.

20 Effects of light stimulation on brain lateralization in developing chicks (*Gallus gallus domesticus*): an immediate early gene study

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Background: Late embryonic light stimulation in a critical window before hatching is known to stimulate selectively the left hemisphere of domestic chicks and to lead to future brain and behavioural lateralised asymmetries. We recently observed a general trend for left lateralisation in newly hatched dark incubated chicks. The left hemisphere usually showed more activity than the right one. This asymmetrical activity pattern was observed in different brain areas (septum, amygdaloid and preoptic nuclei, hippocampus and intermediate medial mesopallium) in different behavioural conditions, regardless of the experimental manipulations. Methods: We devised three experimental conditions: a group of chicks was dark incubated and hatched in complete darkness, a second group was light stimulated during the critical window in egg and hatched in the darkness and a third group was incubated in the darkness and individually light exposed homogeneously after birth. Brain activity was visualised with an immunohistochemical staining of the immediate early gene product c-Fos. Immunoreactive cell density was estimated in the areas, in which we previously observed the asymmetries. Results: Here we observed that newly hatched chicks that were incubated in the darkness and had never seen anything showed significantly higher density of c-Fos-ir cells in the left hemisphere than in the right. A similar trend less pronounced was visible in the other two groups. Late embryonic light stimulation is not necessary for the development of left hemispherical asymmetries.

21 No-movement awareness induces ERP modulations in a Go/Nogo task

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This EEG study focused on electrophysiological processes underlying no-movement awareness (the conscious detection of the impossibility of accomplishing self-generated actions). We contrasted conditions in which participants were free to perform a Go/Nogo task with conditions in which left-hand movements were prevented by a cast. Immobilization effects were tested after the cast-positioning and after one week of immobilization. We predicted a modulation of event-related potentials in blocked-conditions, when subjects tried to perform the task, but movements were precluded. In nogo trials, a modulation of the inhibition-related P300 was found. Only in left (manipulated) side, P300 was reduced in blocked-conditions, suggesting that, when the system “knows” that no-movements can be performed, inhibitory responses are not implemented. In go trials, a modulation of N400, related to semantic/conceptual violations, was found. In our study, the motor-monitoring system could detect a violation when, according to go-signals, motor response was planned but no-movement was performed (due to immobilization). In left side, N400 was

oppositely modulated by blocked- and free-conditions, depending on the day. In blocked-conditions, an enhanced N400 at day1 suggests that motor-monitoring system suddenly detects a mismatch between intended but not executed response. At day2, when motor-monitoring system changed its predictions about the “learned block”, no incongruence is detected. Contrariwise, in free-conditions, a larger N400 at day2 was elicited by the detection of new incongruence between no-movement predictions and the evidence of being able to move again. These findings show that mechanical limb-immobilization is a good model to investigate EEG-activity changes related to no-movement awareness.

22 Motor system inhibition enhances the rubber hand illusion susceptibility

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A recent study showed that, while the subjects had been induced by the rubber hand illusion (RHI) to perceive a fake hand as part of their own body, their primary motor cortex (M1) excitability was temporarily decreased, so that they were less ready to move their real hand. Since an illusory body ownership triggers inhibitory effects on M1, here we aimed at investigate whether and to what extent modulating the excitability of M1 may affect the strength of the illusion. In the Main Experiment, off-line, sham-controlled, low-frequency (1 Hz) repetitive (r)TMS was applied over the left M1; the strength of the illusory experience was assessed by administering the RHI to the hand contralateral to the stimulated M1. In the Control Experiment the RHI was performed in the hand ipsilateral to the inhibited M1. Results showed that 1-Hz rTMS over M1 significantly enhanced the illusory experience, as proved by a significant increase of both subjective (Embodiment/Disembodiment Questionnaires) and objective (Proprioceptive Drift) RHI measures as compared to Sham (Main Experiment). Moreover, the effect was specific for the hemisphere controlling the hand exposed to the illusion. These results provide evidence that, when the subjects are less ready to move their own body (as following M1-inhibition by rTMS), their sense of body-ownership is attenuated and they are more prone to incorporate an alien limb.

23 Boundary based geometry is impaired in old age

Rachel Bhushan, Elisabetta Colombari, Sang Ah Lee

Background: The capacity to find our way towards a target location is of key importance especially when we get lost. So what kind of information from the external environment can we use in order to get to our goal? There are two kinds of information, either the geometric shape of the environment or visual cues called features such as a striped wall or a colorful object. Research in many animal species including human children show that there is a significant preference in using environmental shape to reorient towards a goal location. The neural substrate of boundary based reorientation lie in the boundary cells inside the hippocampus. These neurons increase firing when close to a boundary and therefore are sensitive to environmental geometry. Methods: Given the broad range and validity of boundary-based navigation, we wanted to see if this ability is conserved in old age and across species. Therefore, we designed a behavioral task and tested Lister hooded rats (*Rattus Norvegicus*) as young adults (6 months) and old (2 years) and mice (*Mus Musculus*) at 3 months (adults) and 18 months (old). The aim was to see if they were able to find the target location using boundary geometry alone (condition 1), and featural cue alone (condition 2). Results: Our results indicate that there is a clear impairment in boundary-based navigation in old animals. Moreover, old animals fail to distinguish the striped wall, while young animals use it to focus their searches in the correct location.

24 Do scene context expectations influence attentional templates?

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Background: When we look for something in the environment, we establish an attentional template containing a description of the target object, which guides perceptual processing to template-matching visual items. In a series of behavioural experiments, I investigate whether expectations about the natural context influence the characteristics of search templates. For example, when we look for a person, a template based on low-level features (e.g. “vertical shape”) might be effective if the context is an empty field; however, this template might be ineffective if the context is a forest with many trees (which, being vertical, would match the template and capture attention). In this case, an attentional template based on higher-level features, such as object-diagnostic parts, might be more effective. In these experiments, I investigate whether participants can switch between different types of templates for the same target object based on the expected natural context. Methods: Participants performed behavioural visual search tasks in which they had to look for cars or people in natural scenes (the manipulation of the natural context was not explicit to the participants). Reaction times and response accuracy were recorded. Results: The data suggest that expectations about the natural context do not affect the characteristics of search templates and that they consist of orientation-invariant category features.

25 **The Extent and Decay of Identity Priming in Picture Naming**

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In picture naming, identity priming refers to faster naming of an item due to previously having named it. Significantly reduced response times have been found even at long delays of weeks or even months. However, the vast majority of previous research has used identical pictures at both time points, therefore making it difficult to distinguish effects of priming of word retrieval from priming of picture identification. In this study, we aimed to better discriminate these processes by using different depictions of items when exploring the decay of priming of picture naming across a week and also investigate if there are any effects of ageing on priming. Across three sessions, 24 young adult and 24 older adult participants named 3 sets of 165 pictures which were repeated for naming with a different depiction within session (minutes), or after 1-day, or 1-week. There was a significant main effect of priming and of time delay, and a significant interaction between the two: The magnitude of priming decreased across time. A main effect of age was found but no significant interactions with priming or delay. We have replicated the finding of robust identity priming at a delay of 1 week. However, the effect was much smaller than previously reported, which we attribute to using different depictions. It appears that the mechanism involved in priming, is not affected by ageing.

26 **Measuring and diagnosing unilateral neglect: a standardized statistical procedure**

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Objective: Unilateral neglect is usually investigated by administering stimuli (targets) in different positions, with targets being responded to by the patient (Hit) or omitted. In spite of this homogeneity of data type, neglect indices and diagnostic criteria vary considerably, causing inconsistencies in both clinical and experimental settings. We aimed at deriving a standard analysis which would apply to all tasks sharing this data form. Methods: A-priori theoretical reasoning demonstrated that the mean position of Hits in space (MPH) is an optimal index for correctly diagnosing and quantifying neglect. Crucially MPH eliminates the confounding effects of deficits that are different from neglect (non-lateral) but which decrease Hit rate. We ran a Monte Carlo study to assess MPH's (so far overlooked) statistical behavior as a function of numbers of targets and Hits. Results: While average MPH was indeed insensitive to non-lateral deficits, MPH's variance

(like that of all other neglect indices) increased dramatically with increasing non-lateral deficits. This instability would lead to alarmingly high falsepositive rates (FPRs) when applying a classical diagnostic procedure that compares one patient with a control sample. We solved the problem by developing an equation that takes into account MPH instability and provides correct cut-offs and close-to-nominal FPRs, even without control subjects. We developed a computerized program which, given the raw data, yields the MPH, a z-score and a p-value. Conclusions: We provided a standard method that allows clinical and experimental neuropsychologists to diagnose and measure neglect in a consistent way across the vast majority of tasks.

27 Associative habituation starts before hatching and persists for at least 48 hours posthatching in chicks

Andrea Dissegna¹, Massimo Turatto², Barbara Penolazzi¹, Cinzia Chiandetti¹

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Habituation is considered an example of non-associative learning, depending on stimulus characteristics. This form of learning is documented in birds even prenatally, with effects persisting a few hours posthatching. However, an associative model of habituation suggests that during the stimulus repetition a stimulus-context association is established: habituation to the same stimulus is less likely to transfer to a different context.

We considered 120 chicks (*Gallus gallus*) whose stops of the wheel-running behavior were scored as measure of habituation to 2 sequences of five 250ms-bursts of 90dB white-noise, presented one hour apart, during their second day of life (D2). Chicks exposed to the noise within the same running-wheel the day before (D1), on D2 showed only a residual freezing response (long-term habituation). Conversely, chicks that heard the noise on D1 within the incubator, on D2 showed a more intense freezing performance, showing that habituation was at least partially context specific. Indeed, chicks tested at the same age but never exposed to the stimuli on D1, showed a significantly stronger freezing response although habituating across the two sequences of the same day (short-term habituation). Furthermore, chicks exposed to the noise before hatching, within the egg, showed the same performance of chicks stimulated on D1 within the incubator.

Hence, our results indicate that in chicks habituation of the freezing response varies depending on the history of stimulation, showing that associative mechanisms underlying context-specific habituation are active also before hatching, and that this form of learning can last for at least 48 hours posthatching.

28 How much does vision contribute to our body representation? A comparison between implicit and explicit representation of the hand in case of visual deprivation

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Background: The knowledge about the size and shape of the body, the body metric, can be used both implicitly, in high-level somatosensory processes, and explicitly to judge the dimension of the body parts and to recognize our own body. Surprisingly, the implicit metric of the body seems to be distorted while the explicit one is accurate. These differences might be due to the dissimilar contribution of somatosensation and vision in the construction of each of these representations. Our aim is to investigate the specific contribution of vision in the development of the body metric, comparing sighted, visually impaired and blind participants. We hypothesize that vision has a major role in the construction of the explicit body metric while somatosensation underlies the implicit one. Consequently, we expect that blindness would affect largely the explicit representation and only slightly the implicit one. Methods: To investigate the implicit representation we asked participants to locate their fingertips and knuckles and we used landmarks reciprocal distances to derive the underlying model of the hand. To probe the explicit representation, we asked participants to report the dimensions of their hand adjusting the gap between two metal sliders moving on a rod. Results: According to our hypothesis, preliminary results suggest a more similar implicit representation across groups, while the explicit representation seems to be more heterogeneous.

How input modality and visual experience affect the representation of categories in the lateralized brain

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How sensory input and experience shape the way information is categorized in the brain? And how lateralization of brain functions may impact on this process? We used fMRI to characterize the brain responses to 8 categories presented acoustically in sighted and early blind individuals, and visually in a separate sighted group. We observed that the right posterior middle temporal gyrus (rpMTG) is the region that most reliably decoded categories and selectively correlated with categorical models of our stimuli space independently of input modality and visual experience. However, rpMTG maintained separate representational format between audition and vision; suggesting distinct representational geometries across the senses. Importantly, we observed robust enhancement in decoding auditory categories in the occipital cortex of blind individuals, but only in the right hemisphere, highlighting hemispheric lateralization in the way crossmodal plasticity expresses. When specifically investigating regions typically showing categorical preference for faces (FFA), tools (LO) and scenes (PPA) in vision, we found that the acoustic representational geometry of the stimuli correlated with the visual geometry in both hemispheres in the blind whereas in the sighted such correlation was only observed in the left hemisphere. All together these results demonstrate hemispheric asymmetries in the way input modality and sensory experience impact on the implementation of categorical representations.

Network level taxonomy of the core/extended person perception system

Aidas Aglinskas¹, Scott L. Fairhall¹

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Background: Familiar faces prompt the recall diverse kinds of person-related knowledge (their name, occupation, personal experience, associated social and perceptual traits). The way this information is dynamically encoded within the well-characterised 'face' network (core and extended systems) is still uncertain. Methods: To address this issue we had participants (N=20) perform ten different tasks which required accessing five different kinds of person knowledge (Social, Episodic, Factual, Physical, Nominal). Results: By directly comparing different cognitions, we are able to test relative role of specific cognitive processes in specific brain regions, such as whether the role of the ATL is to process social or nominal knowledge. Furthermore, novel Network level Representational Similarity Analysis (netRSA) provides insight into underlying organisation of face selective regions at the systems-level. The IFG and OFC coordinate closely with early perceptual regions in the core system (FFA, OFA, pSTS) while the Anterior Temporal Face Patch (ATFP) is more consistent with regions belonging to extended system regions. Collectively the results that core and extended system can be characterised by response similarity. IFG and OFC show patterns of response fitting with core-function and are distinct from extended system. Within the extended system, default mode network acts as an independent processing module distinct from other (amygdala, ATFP) extended system regions.

SATURDAY- SESSION C (10:00-11:00)

1 **Project of Cognitive Stimulation in Patients with Mild D.N.C. in Asl To3**

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This is a pilot project that involved 45 patients with mild dementia treated within the Center for Cognitive Disorders and Dementias (CDCD), Complex Structure of Neurology in the Rivoli's Hospital (A.S.L. TO3). It developed from the notions in the literature on neuroplasticity, neurocognitive rehabilitation models, treatment of mood disorders associated with neurological disorders and Alzheimer's caregiving. It is born with the aim to experiment an innovative procedure of treatment of the cognitive deterioration with the purpose to improve the quality of the life and the state of well-being of the patients and of their families in a point of view of secondary and tertiary health promotion. The aspect that makes this project innovative is about the holistic reception of patients. It includes group neurocognitive stimulation sessions with the help of computer programs and paper and pencil material together with group sessions for caregivers. In order to monitor the outcomes, patients and their familiar questionnaires, ratings scales, and neuropsychological tests has been administered before and after the treatment. Based on the preliminary data and the first test results, the results indicate a significant recovery of the main cognitive functions rehabilitated with long-lasting effects (over 6 months of symptom stabilization) of these benefits, both in terms of self-care and daily activities. The neuropsychological stimulation carried out has also had a good impact on the tone of the mood and on the level of self-esteem and awareness of the subjects treated with positive effects also on their caregiver.

2 **Endogenous modality-specific attention influences sensory reliability during multisensory integration**

Ambra Ferrari¹, Uta Noppeney¹

1. *Computational Neuroscience and Cognitive Robotics Centre, University of Birmingham*

To form a solid representation of our world, it is essential to integrate sensory signals coming from a common source and to segregate signals from separate sources. In line with the principles of Bayesian Causal Inference, the brain merges information from different senses weighted by their sensory reliabilities while also taking into account the uncertainty about the causal structure of the environment. The extent to which these integration processes are automatic or susceptible to top-down attentional control is unclear; moreover, the computational mechanisms and the neural underpinnings of this putative relationship are poorly understood. To evaluate the role of endogenous modality-specific attention in multisensory integration we presented participants with synchronous auditory and visual signals that were independently sampled from four azimuthal locations in a spatial ventriloquism paradigm. In a 2 x 2 factorial design subjects were pre-cued to attend to the auditory or visual stimulus and post-cued to report the auditory or visual location. Our results show that attentional validity (given by pre-cue and post-cue congruency) increased spatial localisation accuracy, as quantified by a reduction of the ventriloquist effect. Bayesian Causal Inference model fitting reveals that attentional validity increased the reliability (i.e. inverse of variance) of the incoming sensory information, while prior perceptual and binding tendencies did not

change. Ongoing neuroimaging studies aim to determine the cortical mechanisms by which attention influences sensory reliability during multisensory integration.

3 Synergistic interplays between attention and expectation - A multisensory perspective

Arianna Zuanazzi¹, Uta Noppeney¹

1. Computational Neuroscience and Cognitive Robotics Centre, University of Birmingham

Attention (i.e. task relevance) and expectation (i.e. stimulus probability) are two critical determinants of perception and only recently did studies attempt to dissociate them. While attention is thought to increase the neural response to external stimuli, expectation is considered to attenuate it. Operationally, attention is often manipulated by asking participants to respond only to the 'attended' stimuli. As a result, previous studies have evaluated the synergistic effects of attention and expectation only at the neural level, but not at the behavioural level where 'unattended' stimuli are not responded to. Our study developed a novel multisensory paradigm that allowed us to evaluate the interplays between spatial attention and expectation at the behavioural and neural level. In a series of experiments, we presented participants with auditory and visual signals. We manipulated response requirements and stimulus frequency only to auditory signals, allowing us to measure the multisensory effects of spatial attention and expectation on behavioural responses to visual signals. Our results demonstrate that the behavioural interplays of spatial attention and expectation can be parsimoniously explained by recognizing that attention and expectation in fact jointly co-determine the probabilities that a signal requires a response. Finally, our concurrent fMRI experiment investigated how the multisensory effects of attention and expectation are represented at a neural level.

4 The effects of attention to the contextual integration of objects and scenes

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Context of naturalistic scenes has the power to facilitate object processing in the human brain (Brandman & Peelen, 2017). The representation of objects in the human visual cortex is also strongly modulated by selective attention (Cohen & Tong, 2013). How attention influences the contextual integration of objects and scenes as well as the dynamics of this process remains unknown. To address this question we recorded brain activity of participants using Magnetoencephalography (MEG) while they were viewing degraded (blurred) objects alone or in their natural background preceded by a fixation cross. To manipulate selective attention we showed the same stimuli display in the center of the screen, but asked participants to perform two interleaved tasks: to respond when they see the fixation cross changing its luminance (object-unattended) or when an oddball appears instead of an image (object-attended). The representation of object category (animate/inanimate) was measured by the multivariate response patterns across the scalp, for each point along the time-course of the neural response. Contextual facilitation was defined as the difference in decoding accuracy between objects with scenes and objects alone. This difference was significant for the object-attended condition at around 300 - 400 ms after stimulus onset and not for object-unattended condition. This reveals that selective attention is a prerequisite for the contextual facilitation of objects in scenes in the human brain. The present study demonstrates how the multivariate

response patterns from MEG recordings may unveil temporal dynamics of attention effects on the contextual integration of objects in naturalistic scenes.

5

Children's Quantitative Bayesian Inferences

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Earlier studies showed that infants (Teglas, Vul, Girotto, Gonzalez, Tenenbaum, & Bonatti, 2011) and 4-5 year old children (Girotto & Gonzalez, 2008; Denison, Bonawits, Gopnik, & Griffith, 2013) can draw, respectively, correct implicit and explicit qualitative inferences. Once the symbolic numeric system has been acquired, are children able to draw correct quantitative Bayesian inferences? Zhu and Gigerenzer (2006) showed that an appreciable number of Chinese children aged between 9 and 12 years old made correct quantitative inferences by integrating priors and likelihoods as long as they were presented with numerical information phrased in terms of natural frequencies. In this study, we sought to replicate this finding and extend the investigation of children's Bayesian reasoning to a different numerical format (chances) and other probability questions (distributive and relative). In Experiment 1, a sample of Italian children was presented with the natural frequency version of five Bayesian inference problems employed by Zhu and Gigerenzer (2006), but only a tiny minority of them were able to produce correct responses. In Experiment 2, we found that the children's accuracy, as well as the coherence between their probability judgments, depended on the type of question but not on the format (natural frequency vs. chance) in which information was presented. We conclude that children's competence in drawing quantitative Bayesian inferences is lower than suggested by Zhu and Gigerenzer (2006) and, similarly to what happens with adults, it relies more on a problem representation that fosters an extensional evaluation of possibilities than on a specific numerical format.

6

Monitoring of Movement execution and Goal achievement influences the Sense of Agency

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The Sense of Agency (SoA) - the feeling of controlling one's body to influence external outcomes - is reduced by unpredicted events. We present a novel paradigm which investigates the combined contribution to SoA of movement execution and goal achievement. Thirty volunteers performed goal-directed actions consisting in pressing one of two buttons following a color cue, by lowering or raising their index finger. Participants observed a virtual hand from a first-person perspective acting simultaneously (0 msec delay) or after various delays (75, 150, 225, 300 msec) and Movement (same/opposite) and Goal (success/failure to press the signaled color) were manipulated. We collected *judgments of correspondence* - an explicit index of SoA that overcomes the tendency to over-attribute actions to oneself - by asking participants if the observed action was synchronous or not with their own action. We calculated the proportion of "synchronous" answers for each participant and each condition and entered mean values in a 2x2x5 ANOVA with Movement, Goal and Delay as within-subjects factors. Participants perceived opposite movements as less synchronous, irrespective of the duration of the delay (main effect of Movement). Further, observing a failure to achieve the goal was associated to lower perceived synchrony only when the

observed action was simultaneous (0 msec) or presented after 75 msec (Goal x Delay interaction). These results suggest that SoA is modulated by monitoring both movement execution and goal achievement. Interestingly, goal manipulation was effective only within a short temporal window, suggesting that SoA is more sensitive to movement execution.

**7 Network connectivity underlying the human speech articulation:
a combined direct electric stimulation, resting state fMRI and DTI study**

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Fluent speech production in humans is based on the skill of articulating sounds. A speech articulation network (SAN) has been observed in multiple brain studies typically using either neuroimaging or direct electrical stimulation (DES), thus giving limited knowledge about the whole brain structural and functional organization of this network. In this study 7 right-handed patients underwent awake surgery resection of low-grade gliomas (4) and cavernous angiomas. We combined pre-surgical resting state fMRI and diffusion MRI together with speech arrest sites obtained intra-operatively with DES to address the following goals: i) determine the cortical areas contributing to the intrinsic functional SAN using the speech arrest sites as functional seeds for resting state fMRI; ii) evaluate the relative contribution of gray matter terminations from the two major language dorsal stream bundles, the superior longitudinal fasciculus (SLF III) and the arcuate fasciculus (AF) and iii) evaluate the possible pre-surgical prediction of SAN with resting state fMRI. In all these right-handed patients the intrinsic functional SAN included frontal, inferior parietal, temporal and insular regions symmetrically and bilaterally distributed across the two hemispheres regardless of the side (4 right) of speech arrest evocation. The SLF III provided a much higher frequency and density of terminations in the cortical regions of SAN with respect to AF. Pre-surgical rs-fMRI data demonstrated moderate ability to predict the SAN. The set of functional and structural data provided in this multimodal study characterized, for the first time at a whole-brain level, a distributed and bi-hemispherical network subserving speech articulation.

8 Feedback Processing in Patients with Panic Disorder: An Event-Related Potential (ERP) Study

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Anxiety and depression are two psychological disorders characterized by a pathological tendency towards the self. In performance monitoring, an augmented electrophysiological response evoked by internal signals in patients with anxiety or depression disorder seems to reflect this tendency. Specifically, the error-related negativity (Ne/ERN), an index of error processing based on internal signals, is larger in patients compared to control participants. In the present experiment, we investigated whether the preferential processing of internal signals in patients is linked to diminished and inflexible external signal processing. To this end, the electrophysiological response evoked by external signals was analysed in patients with panic

disorder and in controls. Participants performed a choice-response task where feedback followed each response. In half of the experimental blocks, feedback was contingent on performance (informative) whereas, in the other blocks, feedback was unrelated to performance (non-informative). As a replication of previous studies, patients presented an augmented Ne/ERN, suggesting enhanced processing of internal signals related to errors. Furthermore, the P2 to feedback signals was larger in patients than in controls, indexing enhanced attention to the external signals. Moreover, patients and controls showed similar sensitivity to the feedback information content, suggesting that patients can flexibly allocate monitoring resources to external signals depending on how informative the signals are for performance monitoring. These results suggest that the tendency toward internal signals in patients with panic disorder does not hinder the accurate processing of external signals; on the contrary, external signals seem to attract enhanced processing in patients compared to healthy participants.

9 Animal appearance differentially dissociates object representations in human fMRI and deep neural networks.

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Recent studies have demonstrated a general agreement between behavioral similarity judgments, overlap in neural activity patterns, and representational similarities in “deep” convolutional neural networks. Here we challenge this state-of-the-art by dissociating object appearance (how does the object look like?) from object category (which object category is it?). The stimulus set includes animate objects (e.g., a cow), typical inanimate objects (e.g., a mug), and, crucially, inanimate objects that look like the animate objects (e.g., a cow-shaped mug). Behavioral similarity spaces and deep neural networks showed a strong effect of the animacy dimension, setting the lookalike (and inanimate) objects apart from the animate ones. In contrast, neural activity patterns in ventral occipitotemporal regions did not reveal evidence for the animate division: animate entities and lookalikes were similarly represented, and separated from the regular inanimate objects. Animacy is not represented in ventral visual cortex, despite its importance for human behavior and neural networks.

10 Electrophysiological correlates of voluntary orienting of attention, contextual updating and inhibition of sensory processing in left spatial neglect.

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Using Event-Related Potentials (ERPs) we investigated whether voluntary orienting of spatial attention is spared in patients with neglect (N+) and whether this sparing effectively counteracts deficits in reflexive orienting and in the assignment of motivational relevance to contralesional stimuli. Using a Posner task we assessed ERPs that match voluntary orienting of attention, i.e. EDAN, ADAN and LDAP, and the P3a and P3b components that match the comparison between the expected and the actual position of targets, i.e. contextual updating. N+ showed normal ADAN: this shows preserved supramodal frontal processes that match voluntary engagement of attention. In contrast, both the EDAN, which marks the early/automatic phases of attentional shifts, and the LDAP, that signals the later setting up of facilitatory effects in posterior

visual areas, were suppressed. This uncoupling between anterior and posterior preparatory attentional processes was matched with lesion in the frontal operculum and in the arcuate/superior longitudinal fasciculi. N+ showed enhancement of the P3a in response to invalid targets in the right side of space and a drop of the P3a to invalid targets in the left side. This shows exaggerated and reduced novelty reaction to ipsilesional and contralesional sensory events, respectively. The P3b was reduced for targets in the left side of space though not enhanced for those in the right side. These findings show that in N+ preserved voluntary orienting of attention neither helps defective reflexive orienting nor the perception of the novelty or motivational relevance of events in the left side of space.

11 Age-related influences of distractor processing on visual working memory content

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Ageing is characterized by a lack of efficient selection, which causes reduced performance in different cognitive domains. Here we tested how the numerical symmetry/asymmetry between relevant and distracting information can influence efficient/inefficient selection in a visual working-memory task.

We used a change detection paradigm with relevant and irrelevant salient stimuli presented simultaneously in opposite hemifields. Two groups of participants (Young vs Old) were asked to remember the items in the relevant (target) hemifield, while ignoring those in the irrelevant (distractor) hemifield. Crucially, the number of targets and distractors was manipulated orthogonally, such that in some trials the number of targets and distractors was the same (symmetrical), while in other trials it was different (asymmetrical). At behavioral level, older adults performed worse than younger adults with large target numerosity. The Contralateral Delay Activity (CDA) of the EEG signal, a neural signature of working memory, was computed for each target load by subtracting ipsilateral to contralateral activity over the retention interval (300-900ms after array onset). Results showed that when targets and distractors share the same numerosity (symmetrical condition), the amplitude of the CDA was modulated by target numerosity in both age groups. However, when there was a numerosity asymmetry, only young individuals still exhibited a modulation related to target numerosity. The data reveal that younger adults are capable of retaining only relevant information, independent of the numerosity symmetry. Conversely, older adults seem to retain the elements present in the whole visual field (attended/targets + unattended/distractors), in line with the inhibitory deficit hypothesis.

12 Neural Representation of games and strategies in repeated stochastic games

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Most of real life interactions are repeated, rather than isolated, encounters. Such repeated strategic interactions are modeled in game theory (GT) as stochastic games, where the players play a sequence of different single-shot game. GT assumes that players choose actions in a game according to strategies. The aim of this study is to identify neural representations of both game and strategy information during strategic playing, where either the game or the opponent player may change during the interaction. Forty-one participants played a stochastic game while undergoing functional magnetic resonance imaging (fMRI). They played with six virtual players (following different strategies) two different stage games:

the Prisoner's Dilemma and the Battle of the Sexes. At the beginning of each trial, information about the opponent player (or the game to be performed) was shown on the screen, followed by a delay in which the participant had to represent the provided information. Afterwards, information about the current game (or the opponent player) was shown, together with the choices of the player and the participant in the previous trials. Participants had to make their choice considering all provided information. fMRI data from the delay phase were analyzed to identify neural representations of either game or strategy information. Preliminary results show that game information is encoded by a confined network comprising parietal and prefrontal areas, while strategy information is represented in a much wider frontoparietal network. These findings suggest that different game variables of the same stochastic game are represented by different neural networks.

13 Preference for facial configuration in newly-hatched tortoises

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In neonates of social species, such as chicks of the domestic fowl and human new-borns a preference to attend or orient towards to face-like stimuli have been observed (Di Giorgio et al. 2016). Here we test whether the same preference is present in tortoises too, that are non-social vertebrates. We tested newly-hatched tortoises of four species (*Testudo graeca*, *Testudo marginata*, *Testudo horsfieldi*, *Testudo hermanni*) that were isolated in individual compartments from birth, and therefore were naïve for face-like configuration. As experimental apparatus, we used a rectangular arena, and located two pair of face-like and control stimuli on the sides of the apparatus. We left the subject free of moving around and measured the time spent close to both stimuli. In Experiment 1 we used a face-like stimulus formed with three blobs and a control stimulus where the three blobs were aligned. We observed that the subjects of all species spent a significantly greater amount of time near the face-like stimulus. In Experiment 2 we tested a face-like stimulus vs. a control top-heavy stimulus. Preliminary results show a preference for face-like stimuli in this experiment too, suggesting an ancient origin of preferences for face-like stimuli.

14 Change your mind before you choose! Brain signature of changing food information to improve food choice: An ERP study.

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In the food-rich society, food and food choice are intensively processed. Food preference and choice are predominantly learned and are strongly determined by associations between certain food and food-related information. Thus, strengthening associations between minimally-processed food and the concept of healthiness/sustainability may benefit the promotion of food choice with more minimally-processed food. This study investigated the underlying cognitive processing and neural correlates of changes in food choice. Seventeen healthy Italian adults went through a within-subject experiment. In the evaluative conditioning (EC) condition, pictures of minimally-processed food (both low- and high-calorie food) were paired with words representing healthiness/sustainability. In the control condition, pictures of foods were randomly paired with words representing (un)healthiness/(un)sustainability. After each condition, participants went through a series of tasks: semantic congruency task with Electroencephalography measurement, Implicit Association Test (IAT), explicit ratings of food pictures, and a task meant to emulate food choice in real life.

Reaction times for incongruent trials, IAT scores, and ratings for minimally-processed food significantly increased in the experimental condition. In the semantic congruency task after EC condition, participants showed larger N400s for both minimally- and heavily-processed high-calorie foods, indicating an increased conflict between food and food-related information on healthiness/sustainability. Changes in N400 magnitude were correlated with participants' change in food choice. Thus, participants' implicit associations, explicit ratings, and behavioral choices were successfully changed through EC. The results suggest that the behavioral changes might be the results of changes in the magnitude of the conflict between food and information indexed by N400 marker.

15 Neurocognitive rehabilitation through Brainer software: preliminary protocol.

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Background. Since 2015, a neuropsychological rehabilitation Outpatient Clinic has been operating at ASL TO3, and patients afflicted with mild and major DNC (Neurocognitive Disorders), under the care of Neuropsychology and Psychogeriatric Outpatients Clinics, may attend it. Recently, a specific protocol with Brainer software was conceived. **Methods.** Brainer is based on a web platform and it is provided with exercises having various complexity: complex attention, executive function, learning and memory, language and perceptual motor function. The exercises are selected by referring to a basic neuropsychological evaluation, carried out in order to identify the areas to be strengthened, then providing for a monitoring control, which allows one to re-evaluate the situation and adjust the stimulation. The sessions are performed weekly at the outpatient clinic and, thanks to the web platform, at the patient's home: this mode allows for intensive work on cognitive deficits. **Discussion.** The Brainer protocol has so far been administered to 9 patients. At T0 a cognitive assessment is scheduled with MoCA (Montreal Cognitive Assessment) and ACE-R (Addenbrooke's Cognitive Examination), a psycho-emotional evaluation through the POMS (Profile of Mood States) and an assessment of the management load (administered to the caregiver). After three months of cognitive stimulation, a follow up (T1) is envisaged. In the scientific literature it is clear how cognitive stimulation facilitates slowing down and stabilizing cognitive decline, allows for a strengthening of residual abilities and the stimulation of working memory. Furthermore, it protects cognitive reserve, the mental ability involved in recovery of capacities following brain damage. Preliminary data collected so far from the trial in question resulting from administration of Brainer, have allowed us to highlight, at a qualitative level, an improvement in BPSD (Behavioural and psychological symptoms of dementia), such as apathy, depressed mood and anxiety. In fact, many patients by now are waiting for stimulation encounters as a moment of social contacts, and they thus get an improvement also at the level of thymus.

16 Individual recognition in newborn unexperienced tortoises

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Conspecifics' individual recognition is an ability commonly found among social animals: it has been postulated being essential for successful social interactions; in fact, it is supposed to be at the basis of the evolution of cooperation itself. Being able to discriminate individuals may bring several benefits, allowing to

remember and use information from previous encounters to moderate future responses towards the same individual. To investigate the relationship between individual recognition and the evolution of the sociality in vertebrates, we investigated how young non-social reptiles interact with familiar and non-familiar conspecifics. Newborn subjects of two species (*Testudo marginata* and *Testudo graeca*) were reared in pairs with no experience with any other conspecific until the moment of test. After three weeks, subjects were located in a new arena in pairs with either a familiar or and an unfamiliar conspecific. Overall results show that neonates of both species stay significantly closer to unfamiliar conspecifics than to familiar conspecifics. Interestingly, young tortoises have different social reactions compared to chicks, as in this social species familiar pairs tend stay closer to familiar than to unfamiliar individuals. Nevertheless, the differences we observed between the two experimental groups allow us to infer that tortoises are probably able to recognize conspecifics, despite being Chelons non-social vertebrates.

17 Sound Symbolism in Sighted and Blind. The role of orthography and vision in sound-shape correspondences

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Non-arbitrary sound-shape correspondences (SSCs) have been consistently observed across languages and together with other sound-symbolic phenomena facilitate language acquisition and may be important for language evolution. Yet, it is unclear what makes a sound "round" or "spiky" to the human mind. One possibility is that we automatically map shapes onto the motor representations used to articulate speech sounds. However, some SSCs deviate from predictions based on articulation only, calling for additional mechanisms. We hypothesize that the shape of written letters (spontaneously activated by spoken words) may influence SSCs. We tested this hypothesis, in early blind people, who are exposed to an orthography (Braille) in which letters do not have spiky or round outlines. As predicted, early blind showed SSCs that reflected a pure articulatory approach better than sighted people. Conversely, sighted SSCs were better explained by combining articulation and orthography. This result shed new light on the experiential basis of sound-symbolism, and demonstrates that vision is not necessary to develop sound-shape correspondences.

18 Pantomimes and verb naming: effects of theta burst stimulation over the primary motor cortex

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19 Sensitive period and inherited variability for animacy preferences

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In social species, identifying and approaching animate objects is crucial for the survival from the early stages of life. This is particularly true for precocial species, such as chicks of the domestic fowl (*Gallus gallus*). In line with this idea, chicks preferentially approach objects that show cues of animacy, the property of being alive. We investigated whether genetic variability is present for this predisposition by testing naïve preferences for animacy in three breeds: Polverara, Robusta and Padovana. These breeds had been kept genetically isolated for twenty years in the same farm and were raised identically until the moment of test. In Experiment 1, we tested the first approach response to an animate (accelerating/decelerating) vs. an inanimate (uniform motion) object. In Experiment 2, we tested the approach responses to the same stimuli in a running wheel. To test for the presence of a sensitive period we run Experiment 2 at day 1 and day 3 after hatching, Results suggest that (a) a difference in predispositions for approaching animate stimuli between breeds exists, (b) preference for animate stimuli is present at birth and disappears at day 3 after hatching. In Experiment 3, we investigated the presence of differences in early affiliative responses, by studying aggregation to familiar and unfamiliar companions in the three breeds. All breeds were capable of individual recognition but differed in other social variables, such as overall distance between chicks. Hence, genetic segregation for social behaviours extends after the first hours after birth in chicks of the domestic fowl.

20

Expands Body Schema Boundaries

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A growing body of research has shown that the psychological experience of power causes people to misperceive their height. As such, people perceive themselves as taller when they felt more powerful. Combining research on embodied cognition with that on neurostimulation, we tested whether feeling powerful affects the vertical boundaries of the own body schema by measuring corticospinal excitability.

Participants (N=55) were randomly assigned to feel high power, low power, or positive mood unrelated to power and were asked to view an object positioned either in the peripersonal or in the extrapersonal vertical space. We assessed corticospinal excitability by measuring motor evoked potentials (MEPs) using TMS-EMG co-registration. Results show that in the high power condition MEPs did not differ when the object was in the peripersonal (vs extrapersonal) space. Thus, feeling powerful induces changes in the body representation that is traceable also at the corticospinal level and arises from a remapping of peripersonal space boundaries. Taken together, our findings extend prior work by revealing that the symbolic association between power and height impacts self-perception and the surrounding environment.

21

Cognitive processes underlying forward Induction

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The principle of Forward Induction (FI) as game theoretic solution concept is that a player may be able to infer information about the intended action of the counterpart by considering the actions taken in earlier stages of a game. Our objective is to test whether, and for which subjects, the predictions of FI are supported. We recorded eye movements of 105 participants playing 96 games with different equilibrium

structures. Then, we performed mixture models cluster analysis to group participants according to their patterns of visual analysis. Cluster analysis identified 4 patterns: players in cluster 1 were focused on their own payoffs and best responded against the uniform probability belief over the opponent's actions. Players in cluster 2 and 3 were focused on the last stage of the game and were able to detect equilibrium in games with unique equilibria but not to apply FI. Players in cluster 4 exhibited distributed attention and were able to apply FI. We show that considering the actions taken in earlier stages of the game is necessary and sufficient for FI thinking. Moreover, players who ignored past moves failed in applying FI, although a substantial fraction of them was still able to play strategically in games with unique equilibria.

22 Self-other distinction of tactile states relies on S1 effective connectivity

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Touch supports processes crucial to human social behaviour, adding a bodily dimension to the perception and understanding of others' feelings. Mirroring cortical activity was proposed to underpin the interpersonal sharing of touch, allowing an automatic and unconscious simulation of others' somatic states. There is evidence that both touch processing and observation engage the primary somatosensory cortex (S1). An issue still unsolved is how our somatosensory system differentiates the tactile states from the own body from the mirror touch seen in others. Here we provide the first empirical evidence for a neural marker defining the boundary of self-other distinction of tactile states. Transcranial Magnetic Stimulation combined with Electroencephalography (TMS-EEG) recordings were performed during tactile perception and observation, looking for differences in cortical activation and connectivity between felt and seen touch. The sight of a touch directed to a human body part, but not to an object, triggered an early activation of S1 as a felt touch did, and in both conditions activity propagated to fronto-parietal regions. Critically, seen and felt touches share an effective connectivity network generated in the beta band, which is typically associated to sub-threshold, unconscious, tactile processing, while alpha band connectivity, indexing conscious tactile processing, was detected only for the felt touch. Alpha connectivity within a fronto-parietal pathway featuring somatosensory awareness represents the key to distinguish self and other's tactile states based on shared representations in S1, while the embodied facet of the others' touch appears linked to an unconscious representation of the own tactile state.

23 Typical real-world locations impact the time course of object coding

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Everyday visual environments are spatially structured in that objects often appear at typical locations in space: for example, lamps hang from the ceiling, whereas carpets lie on the floor. As a consequence, objects repeatedly occupy similar visual field locations. The long-term experience with these spatial regularities prompts the hypothesis that the visual system is tuned to such retinotopic object locations. A key prediction is that typically positioned objects should be coded more efficiently. To test this prediction, we recorded electroencephalography (EEG) while participants viewed briefly presented objects appearing in their typical locations (e.g., an airplane in the upper visual field) or in atypical locations (e.g., an airplane in the lower visual field). Multivariate pattern analysis applied to the EEG data revealed that object

classification depended on positional regularities: Objects were classified more accurately when positioned typically, rather than atypically, already at 140 ms, suggesting that relatively early stages of object processing are tuned to typical retinotopic locations. Our results confirm the prediction that long-term experience with objects occurring at specific locations leads to enhanced perceptual processing when these objects appear in their typical locations. This may indicate a neural mechanism for efficient natural scene processing, where a large number of typically positioned objects needs to be processed.

24 The role of the prefrontal cortex in eating disorders: neuromodulation of preconscious perception

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Eating disorders (EDs) are characterized by abnormal and disturbed eating habits. Several studies demonstrated reduced inhibitory control and an attentional bias towards food-associated cues in individuals with eating disorders. The prefrontal cortex (PFC), mainly involved in cognitive control, has been shown to be hyperactive in restrainers and hypoactive in bingers and overweight people. Several clinical studies have reported an improvement in ED symptoms following a modulation of the activity of the PFC through transcranial Direct Current Stimulation (tDCS). To better understand the role of the right PFC for preconscious reward processing and inhibition, and its putative dysfunction in ED, a tDCS study was carried out in 36 participants with different eating habits (restrainers, bingers, overweight people and healthy controls). In a within-subject design anodal, cathodal or sham tDCS were applied over the right PFC (rPFC), with the aim of increasing, decreasing or leaving unaltered, respectively, rPFC neuronal activity, while participants completed a Continuous Flash Suppression (CFS) task. The speed of visual awareness for food and control images was measured through button press. Preliminary results show that the speed of visual awareness (RTs) is modulated by tDCS to the rPFC, with anodal stimulation leading to overall shorter RTs. This modulation is influenced by participants' Body Mass Index (BMI) and eating habits, with higher BMI inducing a stronger effect of the modulation on the RTs. These preliminary results seem to indicate that modulating the activity of the rPFC can induce pre-attentive changes in the perception of food stimuli in ED patients.

25 Feature-based orienting and reorienting of attention

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Stimuli in the focus of attention are detected faster and more accurately than those outside of the current focus. Spatial orienting of attention is investigated with use of validly and invalidly cued targets. Invalidly cued targets increase activity in regions belonging to ventral attention network, especially the temporoparietal junction (TPJ). Thus, its functional role was believed to consist in shifting the attention between locations. Reorienting of attention in the feature-based domain has rarely been investigated as yet. We attempted to determine the involvement of ventral attention network in feature-guided attention shifts using Posner paradigm modified to rely on non-spatial, category cues. By using category cues we also wanted to determine if activity in TPJ may be better explained by processing of congruence between stimuli and expectations. Recently, several studies questioned the role commonly ascribed to temporoparietal junction. Yet, as long as need of spatial shifts of attention and violations of expectancies were

intermixed in these studies, the role of TPJ could not have been concluded. By using category cues we show that activity in TPJ is better explained by processes related to computing the congruence between stimuli and expectations. The role of TPJ appears to be very similar in both spatial and feature attention allocation, and is observed bilaterally.

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26 **Do angry faces prime spatial attention?**

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Task-irrelevant angry faces are known to more strongly draw attention during visual search than do happy faces. Event-related potential research has accordingly shown that angry faces require attentional suppression but happy faces do not. However, it is unclear if this suppression is a product of strategic attentional set against happy faces or if it develops through prior experience with specific distractor stimuli. If prior experience is important, angry faces may become easier to suppress when they reappear in sequential trials. In order to investigate this issue, we designed a behavioral task where participants were presented with a hexagonal array of faces. Five of these were inverted, and participants were requested to detect a tilted inverted face and indicate the direction of tilt. The other face, which was upright, acted as distractor and could express angry, happy or neutral emotion. We recorded reaction times in order to compare the effect of angry, happy and neutral distractor faces on target selection. We were specifically interested in sequential effects in the data: what happens when an angry face appears in two trials? Does this change when the angry face reappears at the same location? Results show a trend towards an interesting interaction: the repetition of angry-face distractors causes a slowing of RT, but repetition of happy-face distractors showing no corresponding effect. This is opposite to the idea that suppression of angry-face distractors becomes easier with experience, and suggests that the salience of these stimuli is maintained even after prior episodes of suppression.

27 **Deceptive behavior in children with typical and atypical development**

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Lying is a complex behavior that serves as a window into many aspects of children's developing minds. Much of the research on development of deceptive behavior focused on the role of children's understanding of false beliefs, but little is known about the role of motivational and social factors that might also influence deception. We investigated this issue by manipulating *motivational* factors - by including a material (toy gift) and a social reward (group identity). Furthermore, because the willingness to deceive might interact with situational *social* factors, we performed two different versions of the experiment: one in which children interacted with two experimenters (high "social apprehension") and another in which children interacted with puppets on a stage. Additionally, in order to assess the efficacy of such factors on a population with atypical social tendencies, we compared the performance of typically-developing children (2-6-year-olds) with that of individuals with Williams Syndrome, a genetic neurodevelopmental disorder often characterized by hypersociability. Our findings show that many of the

youngest children (2-3-year-olds) with typical development can engage in deceptive behavior if social and motivational elements are provided, regardless of their mentalizing ability as measured by the Sally-Anne task. Looking at individuals with Williams Syndrome, they seem to be able to perform deceptive behavior, but unable to maintain it and soon revealing the truth. In conclusion, our results suggest that: 1) children, when sufficiently motivated, engage in deceptive behavior earlier in development than previously thought and that 2) such behaviors might be shaped also by social factors.

28 Neural representation of auditory and visual motion direction in the human middle temporal region: amodal or multimodal ?

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The human middle temporal area hMT+/V5 is a region of the extrastriate occipital cortex that codes for visual motion direction. Even if this region has been traditionally considered as purely visual, recent studies have suggested that part of the hMT+/V5 complex could also selectively respond to auditory motion. However, the nature of this crossmodal response remains unsolved. In this study, we used functional magnetic resonance imaging (fMRI) to comprehensively investigate the representational format of auditory and visual motion processing in hMT+/V5 using a combination of multivariate pattern analysis techniques. We first demonstrate that visual and auditory motion direction can be reliably decoded inside independently and individually localized hMT+/V5. Moreover, crossmodal decoding analysis revealed a certain level of modality invariance in the representation of motion direction in the right hMT+/V5. However, a combination of decoding, pattern similarity and representational similarity analyses unambiguously showed that the brain response underlying auditory and visual motion direction is highly dissimilar. Altogether, these results demonstrate that even if a partial overlap in the response pattern to auditory and visual motion direction exists in hMT+/V5, this region however maintain highly separate response codes for each modality.

29 Resting state functional connectivity of multiple brain networks predicts sequence motor learning

Antonello Baldassarre^{1,2}, Maria Serena Iolanda Filardi², Giorgia Committeri²

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Several lines of evidence indicate that patterns of spontaneous brain activity, indexed by resting state functional connectivity (RSFC), correlate with inter-individual variability in visual, sensory-motor, and cognitive functions. Here we investigated whether the strength of RSFC in multiple brain networks is predictive of implicit sequence motor learning. In Day 1, a sample of 17 healthy subjects were submitted to a short (~20 min) training on a bimanual serial reaction time task (SRTT) consisting of 30 repetitions of the learning sequence, preceded and followed by a random sequence. Before training, participants underwent an fMRI session including resting state scans as well as scans of SRTT with only random sequences to identify task-related networks of interest. Twenty-four hours later (Day2), motor learning was assessed through a retest on the trained SRTT. To directly link the motor sequence learning to the intrinsic brain activity, we conducted a partial correlation analysis between the learning index (difference in reaction times -RTs- between Day1 and Day2) and the RSFC of task-relevant networks, regressing out the behavioral

baseline (mean RTs on Day1). We observed two patterns of behaviorally relevant connectivity, such that a better learning was associated with: i. higher inter- and intra-hemispheric RSFC of the cerebellar network, and ii. higher degree of anti-correlation between default mode and visual/motor networks. Our results indicate that spontaneous brain activity in task-relevant brain networks constrains the acquisition of new motor skills, paving the way for future clinical applications.

SATURDAY- SESSION D (15:30-16:30)

1 **Toward self-tracking of brain activity: challenges and opportunities**

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The spreading of wearable technologies is opening new horizons for the tracking of brain activity. Whereas physical activity recognition is becoming mainstream, the miniaturization of sensors and their incorporation in everyday objects may soon lead to a pervasive and unobtrusive sensing of cognition. Traditional brain tracking approaches directly through e.g. Electroencephalography and Functional Near-Infrared Spectroscopy are becoming less demanding, obtrusive and expensive due to the availability of wearable devices. Moreover, secondary sensing through e.g. eye-tracking, head-mounted displays, or infrared light/cameras allows for an indirect recognition of mental states. These technological advancements enable people to self-track their own brain activity. In this work we outline the results of a literature review of technologies for self-tracking brain activity. We undertook a research on academic literature using Scopus, WoS, PubMed and the ACM Digital Library. Findings highlight current trends and opportunities/drawbacks enabled by brain activity self-tracking, focusing on techniques, designs of systems, and impacts on individuals. We show that technology may be employed not only for the assessment, treatment, and training of cognitive functions in neurological rehabilitation, but also to improve attention and support mindfulness states, giving cognitive assistance during demanding tasks. Moreover, data coming from self-tracking can be employed to increase individuals' "self-knowledge", e.g. by providing neurofeedback to modulate cognition, or delivering real-time prompts to support learning. Finally, we explore how individuals make sense of the collected brain data, suggesting ways to improve current technology designs.

2 **Stepping out of the Chinese Room: Word meaning with and without consciousness**

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What is the role of consciousness in computing words' meaning? Masked priming experiments show that words can prime other words with related meanings (cat – dog), and these priming effects are assumed to reflect the activation of conceptual knowledge in semantic memory. Alternatively, however, unconscious priming effects could reflect predictive relationships between the words' forms, since words that are semantically related are also statistically related in language use. Therefore, unconscious "semantic" priming effects could be due to relationships between words' forms mimicking conceptual relationships, as in Searle's Chinese Room thought experiment. To test this hypothesis, we conducted a priming experiment in which temporal words (e.g., earlier, later) were preceded by spatial words that were processed either consciously or unconsciously. Time is typically conceptualized as a spatial continuum extending along either the sagittal (front-back) or the lateral (left-right) axis, but only the sagittal space-time mapping is encoded

in language (e.g. the future is *ahead*, not *to the right*). Results showed that both sagittal (behind, ahead) and lateral (left, right) spatial prime words facilitated the processing of temporal target words (e.g. earlier and later) when the primes were consciously perceived. On the contrary, only sagittal spatial words led to a priming effect when the primes were made subliminal. Unconscious word processing appears to be limited to relationships between words' forms, and consciousness may be needed to activate words' meanings.

3 Statistical learning and morphological processing in visual word identification

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A large body of literature in psycholinguistics has focused on the visual identification of complex words, such as *deal-er* and *basket-ball*. In particular, masked priming experiments attest that morphological decomposition occurs on any word that has the appearance of morphological complexity, regardless of semantic information, i.e., on *corn-er*, whose meaning has nothing to do with *corn*, as well as on *deal-er*. One hypothesis is that this phenomenon is driven by letter co-occurrence regularity—morphemes are also recurrent clusters of letters and would be identified as such, which would explain why segmentation largely ignores semantics. We tested this hypothesis in a masked priming experiment comparing three conditions: (i) *basente-BASE*, where the prime is a combination of the stem target word and a real suffix; (ii) *baserso-BASE*, where the prime is a combination of the stem target word and a non-morphological unit matched on frequency with suffixes; and (iii) *baseffa-BASE*, where the prime is a combination of the stem target word and a low-frequency non-morphological unit. We find comparable priming in all conditions, suggesting that segmentation relies on the extraction of edgealigned stems and doesn't depend on the presence of an affix or a frequent, non-morphological word ending. We also find that priming doesn't depend on the semantic interpretability of the nonword prime. We will discuss how this set of results challenges existing models of visual word identification.

4 Statistical learning and reading acquisition

Valentina N. Pescuma¹, Maria Ktori¹, Benedetta Cevoli¹, Eleonora Lomi¹, Francesca Franzon^{1,2}, and Davide Crepaldi^{1,3}

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Research in the last thirty years has revealed much about how we acquire literacy. Still, the cognitive mechanisms that allow young humans to become proficient readers are rather unclear. Also, much of what we know is based on highly non-ecological paradigms, which allow good experimental control in the lab, but are far from everyday reading experience. In this study, we attack this limitation by tracking eye movements in school children, aged 8-12 (grade 3-6), administering a natural reading task on age-appropriate stories. The stimuli are two sets of six excerpts selected from kids' books, interleaved with forced-choice comprehension questions. Earlier (e.g., skipping, first-of-many fixation duration) and later (e.g., refixation, total looking time) proxies for word processing will be analysed as a function of word features (e.g., length, frequency, grammatical class) and morphological complexity (e.g., number and length of morphemes). Critically, we will also check for sensitivity to word and letter co-occurrence statistics, so as

to gauge the extent to which literacy acquisition relies on the implicit learning of these regularities. These data will inform theories of learning to read, tying connections between visual word identification and statistical learning.

5 Temporal tuning of face-selective areas differs across semantic processes.

Silvia Ubaldi¹, Scott Fairhall¹

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The extensively studied core and extended network for perceiving and knowing about others provides for a critical aspect of human cognition. Here, to gain a system's level understanding of hierarchical organization and regional coordination, we apply a novel approach to assess the temporal dynamics of this system with fMRI. To determine the differential temporal-tuning of cortical regions, we cognitively overload the system using the rapid-serial presentation of faces in 3 different tasks: 'matching identity', 'deep knowledge' and 'contrast change-detection' experiment. Famous faces and buildings were presented at twelve different ISIs. ROIs were identified by contrasting faces with buildings: core system (OFA, FFA); and extended system (precuneus, mPFC, ATL). Beta-values for each ISI were extracted to determine differential regional temporal-tuning across the system. Temporal tuning in the 'matching identity' task was consistent with a hierarchical processing step with core systems transitioning to contemporaneous processing across the extended system. The 'deep knowledge' task showed elongated temporal tuning for the areas in the extended system, while the perceptual areas did not change compared to the first task. Finally, the 'contrast change-detection' task revealed a longer activation for perceptual areas such as FFA and contracted temporal tuning for areas in the extended system. These results highlight that different semantic processes (task-demand) alter temporal tuning across the core and extended network. Specifically, a perceptual task prolonged processing in the core system while a semantic task modulated prolongs activation across the extended system.

6 THINK! – Language and short-term memory. An ERP study

Matteo Mascelloni^{1,3}, Roberto Zamparelli¹, Francesco Vespignani², Jutta L. Mueller³

1. CIMEC, University of Trento, Italy; 2. DIPSCO, University of Trento, Italy; 3. Universität Osnabrück, Germany

On-line processes related to language comprehension have already been investigated with the use of event-related potentials (ERPs), and their main components are fairly well known (N400, LAN, P600), though the debate on their interpretation is still open. However, studies on how we mentally rehearse sentences are missing and the role of short-term memory in maintaining verbal information remains to be understood. The present study investigates the ERPs related to sentence rehearsal that contains semantic or syntactic violations. Twenty-four healthy adults participated in a two-sessions EEG study in which they were asked to read and then mentally rehearse a sentence word by word, following a rhythm given by visual cues. The result of the reading phase partially confirmed the classical finding (N400 for the semantic condition, P600 for the syntactic one), while, in the thinking phase, different components were found for the two conditions: an early fronto-central negativity in the semantic condition, a late frontal-right positivity in the syntactic one. These results suggest different processes for the rehearsal of different kinds of deviant sentences, and possibly a different load on short-term memory.

7 Computational bias guides cross-modal plasticity of higher-level cognitive function in early blind: the case of arithmetic.

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8 Neuromodulatory (NM) Signals Guide Receptor Placement Learning

Gabriele Scheler¹, Johann Schumann²

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We augment a realistic spiking neural network model with NM receptors (λ) located at selected dendritic and synaptic sites, and a continuous function (κ) for the NM signal, which uses realistic shapes as derived from voltammetry. For dopamine as NM, we model the effects of the main receptor types (DA1, DA2) via ion channels on intrinsic excitability, presynaptic release probability and postsynaptic (NMDA) efficacy. Under signaling from κ , neural responses to input patterns corresponding to behavioral stimuli are highlighted by DA1 sites, and weakened by DA2 sites. There is a considerable deviation in the population code for the stimuli depending on κ . We train the network, using synaptic and intrinsic plasticity and exploring adaptive rules for λ placement, based on experimental results. κ is a global signal that affects a large target area, but it is tightly controlled in time, selecting behavioral stimuli, while local activity adjusts learning at individual sites. DA1 increases with high κ , decays with low κ , mitigated by the internal calcium $[Ca]_i$ (spiking activity). DA2 decrease with high κ , increases with low κ . Spiking activity sets the degree of adjustment ('learning rate'). We measure the signal and noise correlation and the mutual information for the stimuli in the neural network with and without learning. An intriguing observation is that encoding of patterns by λ position allows lasting retrieval of one-time full event memory by storing an extended pattern with great accuracy. Regular pattern storage by frequentist updating with fast forgetting of individual events may be characterized by a lack of concomitant λ learning.

9 How do we decompose foreign words? Comparing masked priming effects in visual word recognition in a native and non-native language.

Eva Viviani¹ and Davide Crepaldi^{1,2}

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2. Milan Center for Neuroscience (NeuroMi), Italy*

Abundant evidence suggests that visual word identification is based on the analysis of the internal structure of words, at different linguistic levels (e.g., orthography, morphology, semantics; Whiting et al., 2015). How these mechanisms apply to a reader's second language is much less clear (e.g., Heyer & Clahsen, 2015; Diependaele et al., 2011), possibly because participants in these experiments were never tested deeply for their individual linguistic profiles. This study takes up this issue by involving L1 Italian-L2 English speakers in a masked priming task where the relationship between prime and target was either morphologically

transparent, e.g. employer-EMPLOY, or morphologically opaque, e.g. corner-CORN; and these conditions were contrasted with an orthographically matched baseline, e.g. brothel-BROTH. Participants took up the task in both their L1 and L2; and, critically, they underwent a thorough testing of their lexical, morphological, phonological, spelling and semantic proficiency in their second language.

Results showed markedly different priming between L1 and L2. Items in a transparent relationship were primed in L1 and L2, whereas opaque items primed only in L1 but not in L2. This general pattern was further qualified by proficiency in L2— low proficiency was associated with priming in all conditions, whereas opaque and orthographic items lost facilitation as proficiency increased. These results suggest that the mechanics of visual word identification change dramatically with increasing proficiency, which goes together with morphological parsing and lexical competition. Interestingly, morpho-orthographic effects didn't emerge in L2 in our sample, even at the highest proficiency.

Diependaele et al. (2011). *Journal of Memory and Language*, 64, 344-358.

Heyer and Clahsen (2015). *Bilingualism: Language and Cognition*, 18, 543-550.

Marelli, M., Amenta, S., & Crepaldi, D. (2015). *The Quarterly Journal of Experimental Psychology*, 68(8), 1571-1583.

Whiting, C., Shtyrov, Y. and Marslen-Wilson, W. (2015). *Journal of Cognitive Neuroscience*, Vol. 27, No. 2: 246-265

10 Spatiotemporal coding in vision and audition: tau and kappa effects

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Previous studies investigating time-space relationships in perception have robustly reported that stimuli closer in space tend to be perceived as closer in time as well, inducing the so called 'kappa effect'. Conversely, stimuli closer in time tend to be perceived as closer in space ('tau effect'). Nevertheless, the within-participant assessment of these effects across sensory modalities remains elusive. In the present study, we investigated the kappa and tau effects in vision and audition to assess whether the processing of the spatio-temporal features of stimulation deploys differently in the two sensory modalities (i.e., space dominant in vision, time dominant in audition). On each trial, three-element sequences, consisting of either flashes or pink noise bursts, were presented. While the first and third stimuli (references) were kept fixed in space and time, the spacing and timing of the middle target stimuli (targets) were randomly varied. Across different sessions, the participants were instructed to judge to which reference the target was closer in space or in time, while ignoring the other domain feature (time or space, respectively). The results demonstrated that in vision, the influence of space on time was significantly higher than the reverse condition (time over space). In contrast, the participants' performance did not differ in the auditory modality: time influenced space and space influenced time at a comparable extent. Taken together, these findings suggest that, while the spatial features of visual information are more efficiently processed than its temporal properties, in audition the spatiotemporal relations are more symmetrically processed.

11 Expectations about the presence and the absence of an object in domestic chicks

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While the cognitive and the neural underpinnings of encoding the presence of objects is well documented in humans and nonhumans, exploring abstract representations of absence are largely unexplored. In four experiments we measured domestic chicks' looking behavior (looking time and left/right eye bias) in response to violation of expectation about an object's presence (which should be behind an occluder but it unexpectedly disappears) and about an object's absence (nothing should be there but the object unexpectedly appears). Chicks showed sensitivity for violations regarding both the object's presence and absence. However, their responses were different concerning our measurements. Regarding the representation of presence, chicks looked longer when the object unexpectedly disappeared compared to an expected disappearance, but not in response to the violation of the absence representation. However, we found a sex dependent bias in eye usage similar to previous studies measuring looking behavior to objects and social partners (Dharmaretnam & Andrew, 1994; Vallortigara & Andrew, 1994). While female chicks used more the left eye to explore the unexpectedly appearing object and the right eye for the expectedly appearing object, males did not discriminate the two events. Our results are in line with former research revealing domestic chicks' remarkable capacities to represent the presence of objects and importantly, we also documented their ability to represent the absence of objects. Female chicks' behavior suggests that they are able to encode abstract information about objects' absence and to use it for object/social partner identification.

12 Prestimulus EEG phase synchronization directs cortical signal propagation in the forthcoming brain response.

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2. *DICATAM – Department of Mathematics, University of Brescia, Brescia, Italy*
3. *Department of Mathematics and Physics, Catholic University of the Sacred Heart, Brescia, Italy*
4. *Center for Mind/Brain Sciences – CIMEC, University of Trento, Trento, Italy*

Unveiling how neural populations are connected to communicate and exchange information at the macroscale is one of the most crucial questions to understand the mechanisms underlying cognition. So far, there is evidence that pre-stimulus functional connectivity can predict subsequent behavior. However, there is still little knowledge on how connectivity is formed and how it is related to stimulus processing. Using a graph theory approach applied to transcranial magnetic stimulation and electroencephalography (TMS-EEG) coregistration data, we show that EEG phase synchronization affect signal propagation between cortical areas, creating pathways of communication for cognitive function. 15 healthy young participants received single-pulse TMS over left primary motor cortex during EEG recording. Pre-TMS phase synchronization was calculated in cortical regions of interest and used to compute several graph measures of the global organization of brain networks. Post-stimulus cortical response was obtained by measuring the amplitude of TMS-evoked potentials (TEPs), following M1 activation, and their localization in the cortical space. Crucially we investigated the relationship between the pre-TMS phase synchronization and the post-TMS responses. We found that EEG phase synchronization predicts both the diffusion of activation across the brain and the activation strength, in addition to the strength of the peripheral response. We also show that single connections within functional networks differ in the specific frequency band, which may be related to the function of the specific communication. We propose that prestimulus EEG phase synchronization can influence the behavioral response to external events by modulating signal propagation across remote regions.

13

Spatial Prototypes in the peripersonal space

Raffaele Tucciarelli, Elena Azanon, Matthew Longo

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Recalling spatial positions of objects from memory in impoverishment conditions is difficult because human memory is not perfect. Therefore, in order to locate objects in space, people use categorical information. For example, when asked to report a dot previously presented in a circle, their responses are *biased* towards specific areas within the figure which have been called *Spatial Prototypes* (Huttenlocher et al., 1991). This strategy increases accuracy at a cost of adding a bias in the responses. In the circle, the prototypes have been observed in approximately the centre of gravity of the four sub-quadrants that one obtains when dividing the circle with a vertical and horizontal line crossing at the centre of the figure. Interestingly, this pattern of biases can be used to map the internal representational structure of objects and space. We thus took advantage of this approach to investigate how people represent the peripersonal space of a person. The task was to report a dot previously presented around an image of a person silhouette depicted from above using the mouse cursor. Preliminary results showed that errors (the vectors from the actual position of the dots to the responses) are not randomly distributed within peripersonal space but show systematic biases towards specific regions. This indicates that people represent the space around the person as a circle and that they might divide the space in a specific configuration. A new method for analysing the prototype effect is also discussed.

14

Honeybees learn flashing light patterns

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Cognitive abilities to extract regularities are necessary to make sense of the numerous stimuli available in the world, and have been documented in several vertebrate species. An open question is whether and to what extent pattern learning abilities are present in insects, whose nervous system has largely evolved independently from that of vertebrates. We know that honeybees are able to process and learn information from the environment, and that they can extract and transmit information during the waggle dance. Little is known, though, on their capacities to extract and generalize patterns from serially presented information available in the environment. Here we investigate the capacities of the honeybee (*Apis mellifera*) to extract temporal patterns from flashing and still lights with the aim of investigating: (a) their capacity to discriminate between patterns of different frequency, (b) their capability of generalization to new stimuli. We trained foragers to run through a Y-maze to gain a sucrose reward by choosing a flashing vs. a still light. After documenting their capability to solve the discrimination task, we probed them with new stimuli and colours.

15

Temporal evolution of access to category-sensitive supramodal knowledge

Elisa Leonardelli¹, Elisa Fait¹, Scott L. Fairhall¹

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Previous research has shown that the brain engages different neural substrates, when retrieving semantic knowledge that is referred to different categories, i.e. people or places (e.g.: is the Big Ben/Margaret Thatcher British?). Here we investigate the temporal aspect of retrieving semantic information specific to faces or places, by exploiting the precise temporal resolution of magnetoencephalography (MEG). Crucially,

we presented the stimuli in two modalities: pictures (PIC) and written words (WW), so to test *supramodal* semantic representations, independently from the process used to access this information. During MEG recording we presented participants with a stimuli-set of (famous) faces and (famous) places, first as WW and then as PIC. Participants were asked to make different judgements: either a simple “shallow-level” judgment (“place or face?”) or a more abstract judgement (if the presented stimulus was Italian or foreign). To test *supramodal* semantic representations, we exploited a multivariate approach: we trained a classifier to identify faces/places specific neural patterns in the PIC modality, and tested it in the WW. Results show that access to faces and place information dissociated in the brain at multiple stages, an early one, an intermediate one and a late one, over a fronto-central topography. Moreover, these processes were delayed of about 80 msec for WW than for PIC. These results show supramodal differential encoding of semantic information for different categories and indicate that these category-selective neural populations come online at multiple stages of the semantic processing.

16 Development of a step sensor interface for mobile EEG experiments

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Institute of Cognitive Science, University of Osnabruck, 2 MRC Cognition and and Brain Science Unit, Cambridge

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17 Different networks for conceptual processing in sighted and blind

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What is the role of visual experience in shaping the way we represent concepts? Recent studies, investigating the neural bases of conceptual processing in sighted and blind have shown striking similarities between the two groups. As a consequence, it has been proposed that visual deprivation (and, by extension, sensorimotor experience) has little or null impact on conceptual processing and organization. Here we use repetition suppression in fMRI to detect areas that compute conceptual similarity in sighted and early blind. Participants listened to word pairs, and had to rate the similarity between the meaning of the two words. In sighted people, words that were semantically similar caused habituation (compared to semantically different words) in ventral occipital areas including the lingual and the fusiform gyrus. In blind participants, instead, habituation was found in perisylvian areas, but not in visual cortices. Conceptual similarity was encoded in two different networks in the two populations: a visual network in sighted and a language network in blind. This results show that visual deprivation modulates the way conceptual similarity is computed in the brain.

18 Functional selectivity for visual radial motion processing in the temporal auditory cortex of early deaf individuals

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It has been suggested that cross-modal plasticity following congenital deafness relates to the original functional specialization of the sensory-deprived cortical regions. For instance, an animal study involving deaf cats showed selectivity for visual motion in the temporal regions typically supporting auditory motion processing. In humans, even if some studies showed enhanced activity for visual motion in deaf people, it remains unclear if cross-modal recruitment is functionally selective to motion processing and involves part of the auditory cortex typically dedicated to auditory motion. Here, we characterized the brain activity of early deaf individuals (ED), hearing controls (HC) and hearing individuals fluent in Italian Sign Language (HS) when involved in tasks requiring the processing of radial, horizontal and biological motion as well as their respective control condition. First, we observed enhanced response to all visual motion conditions in the right planum temporal (PT) and mid-superior temporal sulcus (m-STs) in ED when compared to the other two groups. Crucially, we report functional selectivity for radial motion in the right anterior PT/mSTs and the left posterior PT in deaf individuals, regions typically processing looming sounds. Moreover, we show increased task-specific functional connectivity between these reorganized auditory regions and the middle occipito-temporal motion complex (hMT+/V5) of deaf individuals. No reorganization was observed for horizontal or for biological motion in the temporal cortex of the deaf. We conclude that functionally specific reorganization can be selectively observed in the temporal cortex of the deaf for radial motion processing, suggesting an increased salience for this specific motion direction in congenital deafness.

19

Language & Vision Integration in Computational Models

Raffaella Bernardi^{1,2}, Sandro Pezzelle¹, D. Addison Smith¹, Ionut Sorodoc¹

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The CLIC lab is conducting various computational and behavioral experiments leading to the building of plausible cognitive models that can learn to capture and name quantities seen in images. We have tested state-of-the-art language and vision models on both synthetic and natural images and enhance them, on the one hand, by taking into account linguistic theories on quantifiers and, on the other, by exploiting a multi-task learning procedure inspired by cognitive studies on the acquisition of skills such as comparing quantities and approximate number estimation. Within this context we have investigated whether computer vision models can differentiate images of objects that can be quantified precisely (count nouns, e.g. bicycle) and objects for which only fuzzy quantification can be provided (mass nouns, e.g. flour). In the poster, we will zoom into the results of this latter set of experiments.

20

Intertemporal choice behavior and decision dynamics in pathological gamblers

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When asked to choose between a smaller-sooner reward and a larger delayed one, people tend to discount the future alternative, showing a preference for the sooner-smaller one. This phenomenon, known as temporal discounting, has received increasing attention in the clinical domain because alterations in decision-making processes have been associated with different pathological conditions, such as

pathological gambling, alcohol and drug addiction, compulsive shopping, ADHD, eating disorders, and Parkinson's disease. In this study, we compared intertemporal choice behavior of pathological gamblers (PG) and healthy control (HC) participants by using, for the first time, the process tracing method of mouse kinematics. By applying linear mixed models, we replicated the well-known finding of lower reward-associated subjective values and higher discount rates - as well as preference for sooner-smaller alternative - in PG than HC. Additionally, the analysis of the decision dynamics revealed quite different mechanisms in the two groups PG and HC significantly differed in both the spatial (maximum deviation, area under the curve and x-flips) and temporal (initiation time, motion time and total time) measures, with PG showing more pronounced curvature and uncertainty during the choice as well as higher latencies when selecting the delayed alternative (i.e., for the "later" but not the "now" responses). These findings represent a further step toward the understanding of the alterations of decision-making mechanisms in clinical populations with reward-related disorders, thus paving the way for future use with preventive and rehabilitative purposes.

21 Optimization and characterization of T1-weighted sequences for structural brain MRI at 4T

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Magnetic Resonance Imaging at high fields ($\geq 3T$) may potentially image brain structure and function with unprecedented detail. However it is also prone to be affected by severe artifacts due to magnetic field inhomogeneities. New versions of the MPRAGE sequence, the standard T1-weighted sequence for brain structural imaging, have been recently proposed: a) a multi-echo sequence to overcome the magnetic susceptibility artifacts; b) a sequence combining T1 and Proton Density weighted images (MP2RAGE) to correct for image intensity inhomogeneities. Recently a combination of the two (MEMPRAGE) has been also proposed. However a thorough assessment of the image quality provided by these sequences is missing. In this study, we acquired single and multi-echo T1-MPRAGE and Proton Density weighted images at the CIMEC MRI Lab 4T scanner and combined them to obtain the following sets of images: 1) average of two single echo MPRAGE; 2) average of two multi-echo MPRAGE 3) single-echo MP2RAGE; 4) multi-echo MP2RAGE. We calculated and compared contrast-to-noise ratio (CNR), the quality of brain structures segmentation, and image intensity non-uniformity (INU) across these 4 different type T1-weighted images. We found that the single-echo and multi-echo MP2RAGE images provide higher CNR and better INU correction with respect to the MPRAGE images. On the contrary, the segmentation of brain structures obtained with the latter was more accurate. Since T1-weighted imaging is used to localize and derive quantitative information about brain structures, the results of this study may help clinicians and researchers in designing structural imaging protocols at high fields ($\geq 3 T$).

22 Anodal transcranial direct current stimulation over left inferior frontal gyrus enhances sentence comprehension

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In this study we tested the possibility of enhancing natural language comprehension through anodal tDCS (a-tDCS) over the left inferior frontal gyrus. 44 Italian healthy students participated in the study and were randomly assigned either to a-tDCS (30 min, 0.75 mA) or sham condition. The anode (3x3 cm) was placed over F5 and the cathode (size) was over the supraorbital contralateral region. Participants performed a sentence to picture matching task in which the syntactic complexity of sentences was manipulated by using

3 types of sentences: coordinate sentences (Coord), relative clauses in centre embedded position (R_CE) and relative clauses in the right peripheral position (R_RP). A visual pattern matching task was used as control task. Accuracy was analyzed using general mixed-effects models, with Group (2 levels: anodal vs sham) and Type of sentence (3 levels: Coord, R_CE, R_RP) as fixed factors and participant and item as random factors. Participants performed better in the anodal vs sham condition ($\beta = 0.46$, $SE = .21$, $z = 2.16$, $p = .03$) and in coordinate sentences with respect to R_CE ($\beta = 1.17$, $SE = .33$, $z = 3.509$, $p < .001$) and R_RP ($\beta = 1.33$, $SE = .33$, $z = 4.00$, $p < .001$), while in the control task the two groups did not show differences ($z = 1.643$, $p = .1$). To the best of our knowledge this is the first study showing the possibility to enhance natural language comprehension by means of tDCS, a result of special interest from a neuro-rehabilitation perspective.

23 The role of motivational incentives over visually guided and internally guided motor control

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Motivational incentives play a crucial role during force production, selection and acceleration. However, little is known about their specific roles over visually and internally guided stable contraction. We investigated this through a novel task in which participants, incentivized by reward, produced and kept force using a power grip at different force target levels, with and without visual feedback. The analyses were conducted to compare the motivational effect on force estimation, stable contraction, reaction time and fatigue. We divided the results into four macro-categories. First, during internally-guided conditions (i.e. without visual feedback), participants overestimated their force and performance did not vary as a function of incentive. However, during visually guided force estimation, reward prospect impacted performance with increasing magnitude as the force requested of participants became larger. Second, we found that monetary incentive kept the performance of the participants more accurate during the visually guided condition but not during the internally guided one. Third, we found that during both internally and visually guided force estimation, performance declined in small incentive conditions. Finally, we found that high incentive accelerates the motor performance regardless of feedback conditions. These results show that visual feedback is fundamental during both force estimation and stable contraction and how during its absence even the incentive can't motivate an accurate performance. Furthermore, during the absence of visual feedback, force acceleration and fatigue are affected by monetary incentive that motivates the performance, showing their dependencies from the sensorimotor information.

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24 Generalization of Abstract Patterns in Young Chicks

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Filial imprinting is a learning mechanism that enables young precocial birds to rapidly acquire the features of their social partners. After a first exposure, young chicks show affiliative responses towards objects

recognized as imprinting objects. It is not clear though to which extent chicks can extract the abstract rules of the visual and acoustic patterns associated with the imprinting object. To investigate this issue, we imprinted chicks of the domestic fowl (*Gallus gallus*) on stimuli that followed either of two grammars: AA (two identical items) or AB (two different items). We subsequently tested chicks for generalization, presenting them new items arranged according to the familiar vs. unfamiliar grammar: irrespective of the perceptive features of the imprinting objects, chicks could generalize the abstract patterns observed during imprinting to novel objects. Interestingly, males and females exhibited different patterns of response with males consistently preferring to approach the unfamiliar grammar and females preferring the familiar grammar, regardless of the imprinting pattern. When we manipulated both acoustic and visual stimuli (multi-modal condition), chicks approached the preferred stimulus to a greater extent than when we manipulated only the visual or acoustic stimulus. This shows how visual and acoustic stimuli interact in the representation of the imprinting object. Our data show that filial imprinting is not limited to recognition of social partners but can be used for generalization.