MeeTo

From moving bodies to interactive minds

Friday 25th – Sunday 27th May 2018
Aula Magna del Rettorato, Università degli Studi di Torino, via Verdi, 8 - Torino

Abstracts Book

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Friday 25th – Sunday 27th May 2018
Aula Magna del Rettorato, Università degli Studi di Torino, via Verdi, 8 - Torino

Keynote lectures

Keynote lecture I

Friday 25th May ***12.00 – 13.20***

Cristina Becchio - Seeing mental states: an empirical approach

Keynote lecture II

Saturday 26th May ***9.40 – 10.30***

Leonhard Schilbach – Towards a second-person neuroscience & neuropsychiatry: Insights from behavioral and neuroimaging studies

Keynote lecture III

Saturday 26th May ***14.00 – 14.50***

Natalie Sebanz - Self and other as a unit: The "We" in joint action planning and coordination

Keynote lecture IV

Sunday 27th May ***10.10 – 11.00***

Luciano Fadiga - Action and interaction

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Symposia

Symposium I – Shaping the understanding of the world through action

Friday 25th May ***12.00 – 13.20***

Convener: Annalisa Bosco
Department of Biomedical and Neuromotor Sciences, University of Bologna

In daily life, we are surrounded by multiple objects and events and we receive multisensory stimulations. In this rich context, our brain must select through relevant and irrelevant multimodal signals to pick the necessary information to and finally interact with the physical world by hand and eye movements. In recent years, scientific interest has enabled cognitive neuroscience to identify behavioural and neurophysiological models that describe how motor system dynamically integrates sensory information, social and action context, intention and attentional signals, towards loose and contingent representation of the world. Therefore, this symposium provides a comprehensive view of behavioural mechanisms and computational models that take into account different types of motor behaviors that span from a "low-level" reflex that incorporates complex information, to actions that shape perception or sensory input in collaborative and not collaborative situations. The range of topics covered by the speakers encompasses visual as well as motor, cognitive and computational neuroscience. We bring together researchers from all these fields to offer a unique insight into the impact of action on perception at different cognitive levels.

Contribution 1

Indexing intention and attention through pupil diameter

Alessandro Benedetto
University of Pisa

Contribution 2

The motor experience and its context influence object perception

Annalisa Bosco
University of Bologna

Contribution 3

Action-perception transfer in visual tasks: When behavior shapes perceptual coding

Silvio P. Sabatini
University of Genoa

Contribution 4

Joint action and incomplete information: A game theoretic approach

Vittorio Sanguineti
University of Genoa

Symposium II – The Social Cerebellum

Saturday 26th May ***12.00 – 13.00***

Convener: Frank Van Overwalle

Although the cerebellum is traditionally viewed as involved in motor functions, research since the 1980s revealed that non-motor cognitive functions also play a significant role. However, the social function of the cerebellum has been largely ignored, until a recent meta-analysis in 2014 by Van Overwalle and colleaguous identified activation in the cerebellum in about one third of 350 functional magnetic resonance imaging (fMRI) studies on social cognition. Further connectivity analyses revealed unique cerebro-cerebellar links between mentalizing / sensorimotor networks of the cerebellum and the cerebrum during social reasoning tasks. But what exactly is the cerebellum doing during social cognition? **Frank Van Overwalle** offers the hypothesis that an extension of the typical cerebellar capacity to execute and automatize smooth sequences of one's motions, allowed humans to understand, automatize and generate -- in their mind -- action sequences of the behaviors of others. This is an indispensable requirement to understand actions and emotions of others. To explore this hypothesis, he tested cerebellar patients and found that among many tests, only the generating of the correct order of social actions depicted in cartoons and containing elements of false beliefs (Langdon & Coltheart, 1999) showed significant differences with healthy matched controls, while ordinary (overlearned) actions and mechanical sequences did not reveal differences. **Giusy Olivito** found in 9 SCA2 cerebellar patients pathological changes in cerebellar gray matter (GM) and the main cerebellar white matter (WM) microstructure, as well as reduced theory-of-mind abilities to correlate with these alteration patterns. **Chiara Ferrari** explored the role of the cerebellum in emotion perception and recognition, using transcranial magnetic stimulation (TMS). In three experiments, she found that TMS over the (left) cerebellum impaired participants' ability to categorize facial emotional expressions (explicit emotion perception) and their ability to classify the gender of emotional faces (incidental emotional processing).

Contribution 1

The role of the cerebellum in generating action sequences.

Frank Van Overwalle, Sarah De Coninck, Mario Manto & Peter Mariën
Vrije Universiteit Brussel, Belgium

Contribution 2

Spinocerebellar ataxia type 2 as model to investigate the cerebellar role in social cognition: understanding the cerebellar contribution to autistic-like symptoms.

Giusy Olivito[1,2], Silvia Clausi[1,3] & Maria Leggio[1,3]
[1]Ataxia Laboratory, IRCCS Santa Lucia Foundation, Rome
[2]Neuroimaging Laboratory, IRCCS Santa Lucia Foundation, Rome
[3]Department of Psychology, Sapienza University of Rome.

Contribution 3

TMS over the cerebellum interferes with explicit and incidental processing of facial emotional expressions.

Chiara Ferrari[1], Tomaso Vecchi[2,3], & Zaira Cattaneo[1,3]
[1]Department of Psychology, University of Milano-Bicocca, Milan 20126, Italy
[2]Department of Brain and Behavioral Sciences, University of Pavia, Pavia 27100, Italy
[3]Brain Connectivity Center, National Neurological Institute C. Mondino, Pavia 27100, Italy.

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Talks

Talk session I: Moving bodies I

Friday 25th May ***14.20 – 15.20***

Whole-body throwing kinematics cues provide information on ball trajectory and individual throwing style.

Antonella Maselli
Laboratory of Neuromotor Physiology, IRCCS Santa Lucia Foundation, Roma

In our daily encounters with other humans, predicting the intention and the future outcome of observed actions is a mandatory skill for smooth and successful interactions. In the attempt to investigate the mechanisms of such predictive skills, we performed a series of studies of interactive throwing-and-catching tasks. Our first goal was to explore the nature of the early kinematics cues that could be potentially extracted from whole-body throwing actions to predict the outgoing ball direction. For this, we recorded whole-body kinematics from twenty non-expert participants performing unconstrained overarm throws at four different targets (at 6 m distance). By introducing a novel combination of dimensionality reduction and machine learning techniques, we were able to (i) provide a compact description of complex whole-body throwing kinematics; (ii) identify a limited number of throwing styles, recurrent across different throwers; (iii) pinpoint for each thrower the body segments that, throughout the temporal course of the throwing action, could provide key cues for accurate predictions. The recorded kinematics clearly shows that individual throwing strategies differed considerably across individuals, with corresponding inter-individual differences in the spatio-temporal structure of the thrower predictability. We found that for most participants it is possible to predict the ball direction, with an accuracy above 80%, as early as 400 ms before ball release. Importantly, cues allowing for early predictions (more than 200 ms before release) are typically associated to body parts other than the throwing arm. Interestingly, these body parts varies according to the individual throwing style. These results suggest that, depending on the throwing style of the opponent, an ideal catcher (human or robot) could exploit prior knowledge about the most informative body parts, and of their dependence on the temporal course of the throwing action, to optimally extract information from the observed action. This hypothesis is currently under experimental testing.

Action expectation and social processing: Brain activation in response to communicatively exaggerated kinematics

James P. Trujillo, Irina Simanova, Asli Özyürek, Harold Bekkering

Donders Institute for Brain, Cognition and Behaviour, Radboud University Nijmegen, The Netherlands

Centre for Language Studies, Radboud University Nijmegen, The Netherlands

Certain actions or gestures are inherently communicative, such as waving "hello". It is also possible to communicate with otherwise self-serving acts, such as performing actions or pantomimes to teach or communicate. When communicating through pantomimes, actors exaggerate the kinematics of their movements. This exaggeration is recognized by observers and used to infer social intention. Action expectations may underlie this recognition, subsequently leading to social intention inference. Although the putative mirror neuron (pMNS) and mentalizing systems (MS) are theorized to support these processes, no studies have investigated the interaction between these systems when reading communicative intention from kinematics. We tested whether kinematic exaggeration modulated connectivity between pMNS (premotor) and MS (medial prefrontal cortex) brain regions.

FMRI participants viewed a set of stick-light videos of instrumental pantomimes, recorded in a previous study, which were performed either in a communicative or non-communicative context. Participants were asked to classify these videos as communicative or non-communicative. We used participant responses together with pantomime kinematics to model the "communicativeness" of kinematic exaggeration in each video, e.g. probability of being classified as communicative. We tested whether this calculated "communicativeness" modulated activity in pMNS and MS brain regions (whole-brain regression analysis), and connectivity between these regions (dynamic causal modeling analysis).

Inter-region connectivity and activity was modulated by kinematic exaggeration, dependent upon how the overall act was perceived. Specifically, in videos classified as communicative, both regions responded to communicative exaggeration. Communicative exaggeration decreased pMNS influence (ie. directional connectivity) on the MS, but increased MS influence on the pMNS. In videos classified as non-communicative, the pMNS responded to communicative exaggeration, but the MS did not. Furthermore, communicative exaggeration increased pMNS influence on the MS, while decreasing MS influence on the pMNS. Based on the results, we discuss the role of action expectations and communicative kinematics in social intention recognition.

From Moving Bodies to Distorted Minds: Expectations of Action Bias Social Perception

Katrina L. McDonough[1], Patric Bach[1], Matthew Hudson[2]*
[1]Plymouth University, UK; [2]University of Turku, Finland

Predictive coding models of social perception argue that prior knowledge and expectations about other people and their actions guide our perception of their actions. We have applied a novel paradigm to test this suggestion that action perception can be distorted away from actual observation and toward the prior expectation of the action, in terms of action kinematics. In a series of experiments, participants made predictions about how an actor would reach for an object, given the environmental constraints, such as obstructions or choice of two objects. While observing the action, the actor's hand disappeared mid-way and participants were required to judge the final location. Responses were consistently biased in the direction of the action prediction. This result held when predictions were made implicitly as well as explicitly, when predictions were made online, during the ongoing action as well as prior to action onset, and when responses were made using a touch-screen monitor as well as judging probe positions. Social predictions specifically distorted human action, this did not translate across to non-biological motion. Follow up experiments incorporating a perceptual mask confirm that these effects indeed reflect processing in the perceptual regions. These findings support models of predictive coding, with the view that social perception is hypothesis driven. Top-down expectations of others' actions are generated and compared to incoming sensory information as the action unfolds, resulting in biases on perceptual judgements of observed actions.

Talk session II: Moving bodies II

Friday 25th May ***15.20 – 16.20***

On grasping and being grasped: processing active and passive language in the motor system

Claudia Gianelli, Katharina Hintze, Nina Hosseini-Kivanani
University of Potsdam, Germany

Increasing evidence supports the idea that sensorimotor processes take place in our brains while we observe actions performed by others, or just listen or read about them. This process is referred to as motor resonance and is thought to become detectable during language comprehension both with and without a concurrent motor task. But what happens when instead of hearing "You grasped the ball", we read "The ball was grasped by you"? Is an equal sensorimotor representation "grasping of a ball" activated or there's a differentiation between an action presented in the active and in the passive form?

In order to investigate how active and passive form of action-related sentences impact motor responses, we presented participants with spoken active and passive sentences ("You grasped the ball" vs "The ball was grasped by you") in two separate experiments. In Experiment 1, participants judged the sensibility of each sentence by means of an overt motor task. In experiment 2, continuous EEG recording was collected during a passive listening (experiment 2a) or active motor (experiment 2b, replication of experiment 1) task.

Reaction times, movement times and accuracy rates were analyzed in the behavioral task, while the EEG analyses focused on the effects on cortical oscillations.

Behavioral data from two experiments show that spoken active and passive sentences produce comparable motor effects, with EEG data supporting and complementing these findings.

The relevance of these results for the study of linguistic communication, as well as possible extensions to more interactive settings, will be discussed.

Can nodding and shaking reveal attitudes? A preliminary study of embodied social cognition on head movements

Stefania Moretti
CogniLab, University of Genova

Head nod and shake are meaningful social gestures typically performed in Western culture to communicate agreement and disagreement. A recent study within the embodiment perspective (Moretti & Greco, in press) has found a motor compatibility effect between the two gestures and the truth-value of verbal expressions, such that processing true information automatically activates the simulation of vertical head movements, while processing false information activates the simulation of horizontal head movements. This result was obtained with very simple sentences whose truth-value is objectively established (i.e. "Sugar is sweet"; "Shadow glows"). The present study replicates this experiment, but using as stimuli positive and negative statements about foods whose truth-value is subjectively assessable (i.e. "I love chocolate"; "I hate coffee"). In these cases, evaluating a positive statement as true or a negative statement as false means liking its content, or, vice versa, to dislike it when positive statements are evaluated as false and negative statements as true. Our main goal was to test whether the motor compatibility effect found with truth-values (vertical-true; horizontal-false) could be extended to a more general compatibility with attitudes (vertical-acceptance; horizontal-refusal). 79 participants evaluated as true or false a series of sentences by moving them with the head towards one of the four side of the computer screen, through a software converting head movements into the mouse pointer motion. As expected, a motor compatibility with attitudes resulted: response times were shorter when sentences about liked foods were moved vertically and when those about disliked foods were moved horizontally. This result shed light on the possibility to use head nod (a vertical movement going from up towards the body) as an approach movement, and head shake (going from side to side, away from the body) as an avoidance movement, in social and personality research, in order to measure implicit attitudes.

Talk session III: Representation of space

Friday 25th May ***16.50 – 17.50***

The triangle completion task in children: The development of spatial updating across age

Luigi F. Cuturi[a], Paolo Alborno[b], Giulia Cappagli[a], Gualtiero Volpe[b], Monica Gori[a]
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b: Universitá di Genova, Casa Paganini, DIBRIS, Genoa, Italy

In order to study motor skills and their relationship with allocentric representation of space, much research has taken advantage of navigational and path integration tasks, e.g. the triangle completion task. This methodology tests the ability of updating own position in space by moving with no visual information available. Here, we use the triangle completion task to study spatial updating in children after they perform turning angles of 45°, 90° or 135° to the right or left. Forty children (age: 6-11 y.o.) took part in the experiment. Trajectories were recorded by means of the Kinect (motion sensing device - Microsoft) and the EyesWeb platform (Volpe et al., 2016). After being blindfolded, participants walked along the first two segments that compose the triangle (150 cm and 220 cm long, respectively) by being guided by the experimenter; then subjects were asked to go back to the start position without support thus completing the triangle, i.e. along the third segment. Each turn was verbally signaled and indicated by gently pushing the participant towards the target direction. In order to make the task enjoyable, children were told they were walking through a forest and they had to go back to the start position by doing the shortest path with constant velocity. The results show that younger children have a performance worse than older peers thus indicating the influence of the developmental stage in understanding the turned angle. In particular, indexes as the distance between the ending point of the trajectory and how stable children maintain a straight heading while moving (i.e. directness), show that performance improves later in development (age 9-11 y.o.). By unveiling the changes of spatial updating across development, this work provides the scientific basis for the development of technological platforms that could teach how to discriminate angles of different apertures by walking.

Social Beliefs and Visual Attention: How the Social Relevance of a Cue Influences Spatial Orienting

Miles Tufft, Matthias Gobel & Daniel Richardson
Department of Experimental Psychology, University College London, UK.

We are highly tuned to each other's visual attention. Perceiving the eye or hand movements of another person can influence the timing of a saccade or the reach of our own. However, the explanation for such spatial orienting in interpersonal contexts remains disputed. Is it due to the social appearance of the cue—a hand or an eye—or due to its social relevance—a cue that is connected to another person with attentional and intentional states? We developed an interpersonal version of the Posner spatial cueing paradigm. Participants saw a cue and detected a target at the same or a different location, while interacting with an unseen partner. Participants were led to believe that the cue was either connected to the gaze location of their partner or was generated randomly by a computer (Experiment 1), and that their partner had higher or lower social rank while engaged in the same or a different task (Experiment 2). We found that spatial cue-target compatibility effects were greater when the cue related to a partner's gaze. This effect was amplified by the partner's social rank, but only when participants believed their partner was engaged in the same task. Taken together, this is strong evidence in support of the idea that spatial orienting is interpersonally attuned to the social relevance of the cue—whether the cue is connected to another person, who this person is, and what this person is doing—and does not exclusively rely on the social appearance of the cue. Visual attention is not only guided by salience but also by social relevance. Our ongoing projects continue to investigate this influence of social context on automatic behaviours. In particular, our current paradigms focus on how social context frames the way information is shared between individuals working on joint tasks.

Moving in space in a wheelchair: the embodiment of one's own wheelchair and its effects on navigational space representation in people with spinal cord injury.

Michele Scandola & Valentina Moro
NPSY-Lab.VR, Department of Human Sciences, University of Verona

Recent studies suggest that cognitive functions change in spinal cord injured people[1,2,3] (SCI), supporting to the theories that suggest a role for sensory-motor systems in cognition. Anecdotal reports indicate that SCI incorporate their wheelchair and modify the representation of navigational space. However, to date there are no experimental data. We tested two hypotheses: that SCI incorporate their own wheelchair and that this impacts on the representation of navigational space. 20 paraplegics with complete spinal lesions (i.e., the lower part of the body totally paralyzed and insensitive) participated in two experiments. In the first, embodiment was examined by exploiting the body enhancement effect (i.e., stimuli administered to the body are detected faster than those administered elsewhere). Participants were requested to click on a mouse-key when they saw an LED flashing. The LEDs were positioned on their trunk, their legs and on the wheelchair in three counterbalanced conditions: i) sitting in their wheelchair, ii) sitting in another wheelchair, or iii) with the LEDs on a wooden bar. The SCI's responses were faster for LEDs positioned on the body and their own wheelchair than on the other wheelchair and the wooden bar.

In the second experiment, participants had to assess the slope of a ramp and the distance of a flag rendered in virtual reality. Two counterbalanced conditions were compared with participants sitting in their own or in a different wheelchair.

The results show that when sitting in their own wheelchair, participants estimated the spatial distance to be shorter than when sitting in another wheelchair.

These results indicate that SCI incorporate their own wheelchair and that this modulates their representation of navigational space.

1.Scandola, et al. (2016). Sci.Rep. 6, 24126
2.Pernigo, et al. (2012). Eur.J.Neurosci. 36, 3509
3.Scandola, et al. (2014). Front.Hum.Neurosci. 8, 404

Talk session IV: Movement and interaction

Friday 25th May ***17.50 – 18.50***

Evidence for adaptive utility maximisation in the coordination of meaning in task-focussed conversations

Oscar de Bruijn
Alliance Manchester Business School, The University of Manchester

In many theories of communication it is assumed that joint action is achieved through the coordination of meaning, and much research has been conducted trying to understand how this coordination is achieved. For example, a number of studies have found that speakers and listeners often develop a set of expression-referent mappings which can reduce referential ambiguity and consequently facilitate comprehension. However, coordination of meaning should arguably be considered as merely a tool used to achieve the objectives of the joint action. When such a tool is studied outside the context of what its use is supposed to achieve, only partial understanding is obtained. Therefore, this study set out to explicitly link conversational strategies used in the coordination of meaning to the goals set out for the joint activity.

We developed a task for studying how conversational strategies explicitly contribute to the success of achieving a joint activity, the Dot Game, which allows for accurate numerical measurement of the extent to which the collaborators successfully achieve their objectives. Furthermore, participants were incentivised to maximise their collective reward by explicitly linking their performance to the amount of monetary compensation given. We collected conversational data from 16 pairs of participants who completed 32 rounds of the Dot Game each, half using voice-only (Voice-over-IP) and half using text-only (Instant Messaging) to communicate.

Over 7,500 individual utterances were collected. Significant differences between voice-only and text-only conversations were found in relation to the formulation and production of utterances, and in the use of expression-referent mappings and of other conversational strategies such as trying and hedging. A parameter-free model of participants' performance, based on the theory of computational rationality, suggests that participants used strategies adaptively in order to maximize subjective utility taking into account constraints imposed by the task environment, their information processing architecture and experience.

When sounds convey emotions: sound localization and action pre-planning

Paola Cesari, Michele Geronazzo
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University of Verona

Understanding how people plan their action in relation to a detection of an external sound source is the main aim of this experiment. Several evidences corroborate the strict link between sound and action supporting the idea of the motor system involvement during sound perception. In this research we focus our attention on how individuals react to sounds that reach the space close to their body, the so-called peri-personal space (PPS). Thirty-six individuals were tested and by means of kinematics (MX Ultranet Vicon) and EMG (zero wire System) systems we extracted the individual premotor reaction time to quantify movement planning and action preparation. Subjects were equipped with Hefio headphone individually calibrated for listening to sounds selected from the International Affective Digitized Sounds (IADS) inducing positive negative and neutral emotions. Participants were instructed to keep a standing posture while listening to the sounds having looming characteristics and to raise their arms as fast as possible once the sound stopped.
The analysis considered 5 sounds (2 pleasant 2 unpleasant and 1 neutral) stopping at 5 different distances. After listening to each sound they were instructed to indicate with their right index finger on their left upper arm extended forward where the sound stopped (distance estimation). Premotor reaction time modulated significantly with the distances at which the sounds stopped with an accuracy of few centimeters. Individuals were systematically faster at each distance when reacting to a neutral sound when compared to sounds carrying semantics. For distance estimation individuals were highly precise in locating the distances while the neutral sound was systematically perceived as the closest at each distance when compared with the semantic sounds. The results evidenced the role of sound semantic decoding in action preparation and localization.

Motor Biases and Social Ability in Typically Developing Children

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City, University of London

A common failing of investigations of cognitive development is to neglect motor processes foundational behaviors that support higher cognitive functions. Reports indicate that early disruption to motor development can inhibit experience for combining perception and action, precipitating knock-on effects to the attainment of higher, more abstract, and seemingly unrelated cognitive functions (1). The Motor Biases and Social Ability (MBSA) study seeks to understand the links between, motor behavior and social cognition in typically developing children.

Despite the superficial symmetrical appearance of the human body, some motor behaviors are strikingly biased to one side. Motor biases represent an evolutionarily old dissociation of specialized processing of the left and right hemispheres (2---3). At the population---level, strong lateral motor biases for specific behaviors are correlated with typical cerebral lateralization of function and cognitive development. On the other hand, the frequency of weak motor biases rise in populations of individuals with neurodevelopmental disorders and mental health conditions (4).

The MBSA study tested four and five year old children (n = 99) on a behavioral battery of social-cognitive and motor tasks. The study identified the strength of motor bias for holding social and control stimuli alongside additional tasks to evaluate social and cognitive abilities.

Results indicated a population-level left-side holding bias (LHB, favoring the left visual field). Moreover, children with a LHB demonstrated significantly higher mean social ability scores and lower mean impulsivity scores compared with children with a right-side holding bias. Motor biases appear to be present and visible in childhood. As a result, variations in motor phenotypes could act as early behavioral biomarkers of cognitive development, enhancing our understanding of the links between motor behaviour, cognition and neuropathology.

1.Whyatt CP & Craig CM (2012), Journal of Autism and Developmental Disorders, 42(9), 1799-1809.
2 Rogers LJ (2002), Nature Reviews Neuroscience, 4:37–48.
3.Vallortigara G (2000), Brain and Language,73:189–219.
4.Rodriguez A et al. (2010), Pediatrics 2010;125(2):340–8.

Talk session V: Joint actions

Saturday 26th May ***14.50 – 15.50***

Social modulation of affordances: Task sharing joint affordances in a bimanual affordance task

Shaheed Azaad & Simon Laham
Melbourne School of Psychological Sciences
The University of Melbourne, Australia

Gibson (1979) describes *affordances* as the set of possible actions an environment provides for an individual. However, given that many actions require coordination with a co-actor, a fundamental question remains about how co-action modulates the perception of affordances. A growing body of joint action research highlights the extent to which engaging in co-action influences our perception and cognition, in a way that facilitates coordination. In the present study, we use a task-sharing paradigm (Sebanz, Knoblich & Prinz, 2003) to show that acting with a co-actor creates shared grasp affordances in a novel bimanual task. Pairs of participants completed a joint go/no-go task in which stimuli were coloured photographs of 5 unimanual (e.g. handbag), and 5 bimanual (e.g. hamper) grasp-affording objects. Participants made keypress responses with the hand correspondent with their seating position (e.g. participants seated to the left used their left hand) while their non-responding had was tied to their leg. Image colours (red, blue, yellow) cued one of three response options: participant A go/participant B no-go; participant B go/ participant A no-go; participant A and B go (joint trials). We found a 2(Response: individual vs joint) x 2(Affordance: unimanual vs bimanual) interaction effect on response times, indicating a relative facilitation of joint trial response times for bimanual objects. We argue that acting with a social partner creates a shared grasping affordance – effectively distributing the bi-manuality of response across dyads. Moreover, our study demonstrates the utility of a novel, bimanual stimulus-response-compatibility paradigm in exploring affordance perception, that side-steps spatial confounds.

Behavioural and Neurophysiological Evidence for a Dyadic Motor Plan in Joint Action

Lucia Maria Sacheli[1,2], Elisa Arcangeli[1], Chiara Verga[1], Eraldo Paulesu[1,2]
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2.IRCCS Istituto Ortopedico Galeazzi, 20161 Milan, Italy

What mechanisms distinguish interactive from non-interactive actions? To answer this question we tested participants in a series of experiments requiring them to take turns playing music with a virtual partner: in the interactive joint action condition, the participants played a melody together with their partner by grasping (C note) or pressing (G note) a cube-shaped instrument, alternating in playing one note each. In the non-interactive control condition, players' behaviour was not guided by a shared melody, so that the partner's actions and notes were irrelevant to the participant. In both conditions, the participant's and partner's actions were physically congruent (e.g., grasp-grasp) or incongruent (e.g., grasp-point), and the partner's association between actions and notes was coherent with the participant's or reversed. Performance in the non-interactive condition was only affected by physical incongruence of movements, whereas joint action was only affected when the partner's action-note associations were reversed. By applying the same experimental paradigm to fMRI we also show that these behavioural results are paralleled by a modulation in the recruitment of fronto-parietal simulative areas during the observation of the partner's action in joint action as compared to the perceptually-matched non-interactive condition. Altogether, these results show that task interactivity shapes the sensorimotor coding of others' behaviours, and suggest that joint action is based on active prediction of the partner's action goals and effects rather than on passive action imitation. We suggest that such predictions are based on Dyadic Motor Plans that integrates both the agent's and the partner's contributions to the achievement of the interaction goal.

Modulating action duration to establish non-conventional communication

Cordula Vesper[1,2], Laura Schmitz[3], and Günther Knoblich[3]

[1] School of Communication and Culture – Semiotics, Aarhus University, Denmark;

[2]School of Culture and Society – Interacting Minds Center, Aarhus University, Denmark;

[3]Department of Cognitive Science, Central European University, Budapest, Hungary

In many joint actions, knowledge about the precise task to be performed is distributed asymmetrically such that one person has information that another person lacks. In such situations, interpersonal coordination can be achieved if the knowledgeable person modulates basic parameters of her goal-directed actions in a way that provides relevant information to the co-actor with incomplete task knowledge. Whereas such sensorimotor communication has frequently been shown for spatial parameters like movement amplitude, little is known about how co-actors use temporal parameters of their actions to establish communication. The current study investigated whether systematic modulations of action duration provide a sufficient basis for communication. The results of 3 experiments demonstrate that knowledgeable actors spontaneously and systematically adjusted the duration of their actions to communicate task-relevant information if the naïve co-actor could not access this information in other ways. The clearer the communicative signal was the higher was the benefit for the co-actor's performance. Moreover, we provide evidence that knowledgeable actors have a preference to separate instrumental from communicative aspects of their action. Together, our findings suggest that generating and perceiving systematic deviations from the predicted duration of a goal-directed action can establish non-conventionalized forms of communication during joint action.

Talk session VI: Coordination

Saturday 26th May ***15.50 – 16.50***

Observation of communicative cues makes human interaction more meaningful: Evidence from EEG

Dimitrios Kourtis[1], Pierre Jacob[2], Natalie Sebanz[3], Dan Sperber[3, 2], Günther Knoblich[3]
[1]Psychology, Faculty of Natural Sciences, University of Stirling, Stirling, Scotland, UK
[2]Institute Jean Nicod (CNRS, EHESS, ENS), Paris, France
[3]Department of Cognitive Science, Central European University, Budapest, Hungary

We investigated whether the observation of communicative cues between two agents makes their subsequent interaction that involves attending to the same or to different objects more meaningful to the observer. EEG was recorded while participants watched sequences of three photos depicting two actors (a "communicator" and a "recipient") seated at adjacent sides of a table, on which two nearly identical objects were placed at equal distances form each participant. In the first photo, the two actors directed their eye gaze towards each other's eyes, but in 50% of the trials the recipient had his/her eyes closed. In the second photo, the communicator pointed and looked at one object, while the recipient either perceived the pointing gesture (50% of the trials) or had his/her eyes closed. In the third photo, the communicator kept looking at the same object and the recipient either looked at that object (i.e. shared focus of attention in 50% of the trials) or looked at the other object. The analysis was focused on ERPs that were elicited by the third photo, namely the N300 and the N400, which are associated to stimulus identification/categorization and integration of meaning into context, respectively. The N300 was smaller when the two actors shared their focus of attention, possibly because this is a generally more expected interaction outcome, which suggests that identification and categorization of actor-objects relationships is a relative fast process. More importantly, the N400 was smaller when the final photo had been preceded by mutual eye gaze or by perception of the pointing gesture, regardless of whether the two actors finally shared their focus of attention or not. This suggests that perception of communicative cues "opens up" the mind of an observer to different action possibilities, enabling him/her to assign meaning to typically unexpected interaction outcomes.

Emergent coordination in cooperative and competitive joint action

Francesca Ciardo, Agnieszka Wykowska
Istituto Italiano di Tecnologia, Genoa, Italy

Effective social interaction relies on co-agents' ability to coordinate their actions in time. Recent studies (e.g. Malone et al., 2013) proposed that cooperation in joint tasks could result from the emergent coordination of co-agents' responses, rather than a shared representation of the task. Aim: The present study aimed at examining response coordination in cooperative and competitive joint tasks.

In two experiments, we investigated the contribution of interpersonal entrainment in the emergence of Joint Simon effect (JSE). In both experiments, participants performed a go/no-go Simon task alone and together with another agent in two consecutive sessions, respectively. In Experiment 1, they were instructed to cooperate during the social task, while in Experiment 2 participants were required to compete against each other. We examined reaction times and behavioral coupling (i.e. the percentage of emergent coordination between co-agents responses) as a function of instructed competition or cooperation.

Cooperation and competition differently affected the JSE and behavioral coupling. For the group receiving the instruction to cooperate, JSE was observed in the joint, but not the individual, session. No such differential effect was observed in the group with competitive instruction. In addition, for the cooperative group, results showed a higher percentage of emergent coordination between co-agents' responses (i.e. behavioral coupling), relative to the individual condition (Experiment 1). No differences in the percentage of responses coordination occurred between the two conditions when co-agents were in competition (Experiment 2).

Our results show that emerging coordination increases during joint action only if co-agents' goals are shared but not when co-agents' goals are mutually exclusive. Taken together, our data highlight the importance of shared representations in cooperative joint tasks and suggest that emergent coordination in joint task might rely on goal sharing.

Emergent Coordination in Joint Interception

Frank T. J. M. Zaal[1], Niek H. Benerink[2], Daphne van Opstal[1], Remy Casanova[2], & Reinoud J. Bootsma[2]

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In many situations in daily life people show coordinated behaviour to attain a shared goal. In the present contribution, we consider a "doubles-pong" task, modelled after sports situations in which teams of players have to intercept a ball (e.g., receiving a volleyball serve). In the "doubles-pong" task, two players each control a paddle on a shared screen. Their task is to make sure that a ball that moves from the top to the bottom of the screen will be intercepted by one on them, also avoiding a collision between the paddles (for details, see Benerink, Zaal, Casanova, Bonnardel, & Bootsma, 2016). The teams showed a clear division of labour, with a boundary between interception domains but also some overlap. We suggest that this division of labour between the two players emerges from the continuous visual coupling of the player-controlled paddles and the ball. That is to say, on many trials both players initiated a movement, which was aborted by one player when the other player was on an interception course, specified through the changing triangular relation among ball and paddles. Rather than being based on a tacit shared understanding of a boundary between interception domains, the boundary emerges from the unfolding dynamics of the player-player-ball system. The present contribution will show the effects of different initial paddle locations (symmetrical and asymmetrical; Benerink, Zaal, Casanova, Bonnardel, & Bootsma, 2018a) and of differences in proficiency between the two players making up the team (Van Opstal, Benerink, Zaal, Casanova, & Bootsma, 2018b).

Benerink et al.(2016 . Frontiers in Psychology, 7, 1910.
Benerink, et al. (2018a). Human Movement Science, 57, 134-148.
Van Opstal, A. A. M., Benerink, N. H., Zaal, F. T. J. M., Casanova, & Bootsma, R. J. (2018b). (manuscript in preparation)

Talk session VII: Neurodevelopment

Saturday 26th May ***17.20 – 18.20***

Joint goal representation in infants: a fNIRS study

Katarina Begus, Arianna Curioni, Gyorgy Gergely, Guenther Knoblich*
Central European University, Department of Cognitive Science

Infants' goal attribution, and subsequent prediction of future goals of others, is restricted to actions that are efficient. If infants observe agents taking unnecessary detours towards a target, infants do not attribute nor predict agents' future goals (Hernik & Southgate, 2012). In contrast, adult studies investigating coordination of two agents, have shown that trajectories detouring from the optimal path can have a communicative function, serving the joint goal of coordination (Candidi et al, 2015). Using fNIRS, we investigate whether 9-month-olds would perceive individually inefficient actions as goal-directed, if these actions are performed in the context of two agents coordinating towards a common goal. Analysis was focused on activity in the parietal and temporal region as, analogous to adult data (Hamilton & Grafton, 2006), left parietal regions showed repetition suppression for repeated goals and a release from suppression for new goals in infants when observing individual efficient actions (Southgate et al, 2013). Our results indicate a release from suppression in the right superior temporal sulcus when infants observed two agents coordinating towards a new goal, and repetition suppression when the goal was repeated. These results suggest infants attributed a joint goal to the agents despite both agents' actions being individually inefficient, indicating that infants may represent joint actions differently to the sum of individual actions, and that perceptual cues to cooperation may override efficiency when infants process social goals.

When social and action space diverge: a study in children with Autism Spectrum Disorders

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The space around the body has defined both as action space, i.e., peripersonal space, and social space, in which the interactions with others occur, i.e., interpersonal space. These spaces are plastic: peripersonal space can be extended by tool-use, and interpersonal space can be reduced following a social interaction. Recent studies revealed that interpersonal space is larger and less plastic in children with autism (ASD) than in children with typical development (TD). An intriguing question is whether autism affects the regulation of the space around the body as a whole or, alternatively, it selectively affects interpersonal but not peripersonal space. To this aim, TD and ASD children were submitted to the Reaching- and Comfort-distance tasks, to assess peripersonal and interpersonal spaces, respectively. Participants moved toward a confederate or toward an object of similar size. They were asked to stop when they could reach the stimuli (Reaching-distance task), or when they felt comfortable with stimuli's proximity (Comfort-distance task). Both tasks were performed before and after a cooperative tool-use training, in which participant and confederate actively cooperated to reach tokens placed beyond reaching distance. Interestingly, in TD children, following the cooperative tool-use training, an extension of peripersonal space and a selective reduction of interpersonal space with the confederate were found. Conversely, in ASD children, peripersonal space was extended as with TD children, whereas interpersonal space failed to change after training. These results demonstrate a functional dissociation between action and social spaces, and a deficit confined to social space regulation in autism.

The Multisensory Base of Bodily Coupling in Face-to-Face Social Interactions: Contrasting the Case of Autism with the Mobius Syndrome

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In recent years, the perennial question of how we understand others' emotions and mental states has undertaken an "interactive turn" emphasizing the crucial role of low-level bodily coupling and second-personal engagements with others (Gallagher 2008; Schilbach et al. 2013) as opposed to the individualistic procedure of mental state attribution or "mindreading" (Baron-Cohen et al 1999). However, this raises the important question of what counts as foundational for socio-emotional understanding: high-level mentalistic abilities, low-level bodily coupling, or an integrative combination of both? For example, recent findings on face-based emotion-recognition in individuals with Mobius Syndrome (MS) (Bogart & Matsumoto 2010) – a rare form of congenital facial paralysis which prevents facial mimicry (Briegel 2006) – cast doubt on the idea that bodily coupling is the foundational component for socio-emotional understanding (cf. Krueger and Michael 2012). Rather this seems to support a pluralistic and integrative model of social cognition and interpersonal understanding according to which mentalistic and embodied strategies are equally foundational. In this paper we argue that the MS case does not pose a threat to the idea that low-level bodily coupling processes are foundational for social cognition. Rather, despite their lack of automatic facial mirroring MS people might benefit from spared multisensory integration processing which allows them to establish alternative channels of bodily coupling, via different sensory modalities (e.g. auditory, tactile, etc.). We illustrate this by contrasting MS- and autistic persons' use of compensatory strategies in dealing with their social impairments and argue that this comparison might help us to shed light on the constitutive and foundational role of low-level bodily coupling for socio-emotional understanding.

Baron-Cohen S et al.(1999). European Journal of Neuroscience 11(6):1891–1898.
Bogart, K., and Matsumoto, D. (2010). Social Neuroscience 5, 241–251.
Briegel, W. (2006). Clinical Genetics. 70, 91–97.
Gallagher, S. (2008). Consciousness and Cognition, 17, 535–543.
Krueger J., Michael J. (2012). Frontiers in Human Neuroscience. 6: 81.

Talk session VIII: New technologies for the study of interaction

Saturday 26th May ***18.20 – 19.20***

Uncovering mechanisms of social cognition with the use of experimental protocols involving a humanoid robot

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In daily social interactions, the human brain engages various mechanisms of social cognition, such as orienting of attention to where others attend. However, the exact conditions which elicit mechanisms of social cognition are not yet clearly understood. We address this by using experimental protocols involving an interaction with humanoid robots. This allows maintaining excellent experimental control while introducing embodied presence of an interaction partner, thereby increasing ecological validity. In a series of studies, we examined joint attention with (i) a gaze-cueing paradigm in which the iCub robot cued participants' attention by means of gaze/head direction (Experiment 1&2); and (ii) a gaze-following paradigm with robot's gaze being contingent (or not) on participants' saccades (Experiment 3). In Experiment 1&2, we additionally manipulated validity of cues (non-predictive vs. counter-predictive) and social engagement – mutual or avoiding gaze of iCub prior to gaze shift. Results showed that gaze cueing effects were modulated both by social engagement and validity: for non-predictive cueing protocol, mutual gaze resulted in larger gaze cueing effects than avoiding gaze. For counter-predictive cueing, the pattern was reversed. Engagement ratings revealed that mutual gaze induced higher level of subjective engagement than avoiding gaze, independent of validity of the gaze cues. Experiment 3 showed that participants' return saccades to iCub's face were faster when iCub followed participants' gaze, as compared to when its gaze was incongruent with the direction of participants' saccades. In addition, the robot which followed gaze of participants was evaluated as more likeable and human-like, as compared to the robot whose gaze was more often incongruent with that of participants. In sum, these data show that joint attention is influenced by several factors which can be examined in more naturalistic interactive scenarios, but are often missed in classical observational experimental protocols with passive stimuli presented on the screen.

Knowledge transfer during dyadic physical interaction: learning and generalization

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Robotics, Brain and Cognitive Sciences Unit, Istituto Italiano di Tecnologia, Genoa, Italy

Physical interaction between two subjects to accomplish a joint task has been widely studied in the last years. However how a shared representation of the task is learnt by each subject and how mechanisms of collaboration/competition emerge is still unclear. In this study we want to understand in which way the internal representation of the task is encoded in the motor memory. In particular, here we present a study in which two groups of subjects performed a task in dyads, physically interacting in the balancing of a virtual mass immersed in an unstable force-field. The interfaces for the two subjects to interact were different robotic devices for each group that had the purpose of emulate the dynamics of the task. The experiments were divided into two stages. During the first stage (learning) the subjects had a training session in dyads where one subject was proficient in the task and the other naïve. In the first group the naïve subject interacted with a distal part of the upper body (wrist) while in the second with a proximal one (shoulder and elbow). During the second stage (generalization) the naïve subjects of both group were tested alone: they had to perform the same task bimanually with a proximal part of the upper body (shoulder and elbow). Results show that, at the end of the first stage, the two groups mastered to accomplish the task with the same performance. Surprisingly, at the end of second stage, both groups resulted in similar generalization performance even if one group was trained with a different part of the upper body. This result push in the direction that the internal representation of the learnt dynamics do not depends on the end-effector used to interact with the environment but it is encoded at higher level in the motor memory.

I move, therefore I am (?): Active control increases sense of ownership over a virtual limb in a reaching-like task

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Understanding ourselves and our actions is of utmost importance to interact with others and the environment. Sense of agency (attribution of the authorship of movement) and sense of ownership (recognizing a body part as own) are key aspects of self-representation. However, the importance of control over a movement in eliciting sense of ownership is still unclear. In some contexts, it has been found that active control increases sense of ownership, while other studies have failed to find this relationship. In an immersive virtual reality environment, thirty-seven participants reported their subjective sense of ownership and sense of agency over a virtual limb, in a no-movement and active control conditions. The virtual hand could appear either attached to the body, or in a missing forearm condition. The missing forearm condition induced significantly lower ownership scores when subjects were not able to control the arm (lowering reported sense of ownership). However, this was not the case once they could actively control the virtual arm. Also, we found that active control did not increase sense of ownership in the full arm condition, when the baseline scores were already high even in the no-movement conditions. However, in lowered ownership conditions participants reported a significantly higher ownership score while controlling the virtual arm than with the arm at rest. Our results are consistent with active control adding evidence in owning a body, but only when sense of ownership is comparatively low. Also, our results also show that, when participants are divided according to their basal ownership score, modulations of ownership (detached arm condition) affect only a subset of individuals. We believe that understanding the relevance of motor action and individual susceptibility to ownership manipulations is a first step in the study of self-other action attribution in social interaction.

Talk session IX – Mini symposium: The body in the brain

Sunday 27th May ***11.00 – 12.00***

The body in the brain: introduction to the mini symposium

Francesca Garbarini
University of Turin

Me, my hand, and I: Repeated stimulation highlights a possible correlate of self-body recognition in visual ERPs

Irene Ronga, Mattia Galigani, Carlotta Fossataro, Valentina Bruno and Francesca Garbarini

SpAtial, Motor & Bodily Awareness – Research Group, Psychology Department, University of Turin, Turin, Italy

To recognize our own hand, we do not usually resort to vision at all. Conversely, visual attributes are crucial to distinguish other people hands. Nonetheless, previous research demonstrated that subjects are more efficient in recognizing images representing self-body effectors rather than others' body effectors (i.e. *self-advantage*).

Here, we exploited habituation/dishabituation phenomena (i.e. response amplitude modulations induced by stimulus repetition *vs* stimulus change), to highlight possible neurophysiological correlates of the self-advantage in visual Event-Related Potentials (ERPs).

ERPs were elicited by two consecutive visual stimuli (S1 and S2), delivered at a constant 1-second interval, representing either participant's own hand picture (A) or other people hand pictures (B1; B2; B3). Data were collected in two different experimental conditions. 1) In *With-self condition*, stimulus pairs might contain participant's hand; 2) in *Without-self condition*, self-hand was never presented. In both conditions, trials were composed either by two identical stimuli (e.g. AA; B1B1) or by two different ones (e.g. AB1; B1A). Participants were asked to decide whether S2 was identical or different from S1. Accuracy and response times were collected.

From a behavioural point of view, results confirmed the presence of the self-advantage: participants responded faster and more accurately when the self-hand was included in the pair. Conversely, in *Without-self condition* no significant difference was observed.

Crucially, ERP results paralleled behavioural findings. In particular, we found that the difference between habituated *vs* dishabituated responses, with a larger N200 component for dishabituated responses, was significantly greater when S2 represented the self-hand.

Previous studies highlighted the role of N200 in signaling contextual mismatches in visual attributes. Here, we propose that the greater modulation of N200 component in response to self-related stimuli may represent the neurophysiological counterpart of self-advantage observed behaviourally. Altogether, the present findings seem to provide novel hints on self-body implicit recognition.

Inhibitory motor response with a phantom limb: an ERP study

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Phantom limb is a common sensation after a limb has been amputated. Sometimes people with phantom limbs report vivid experiences of voluntarily moving their phantom. Several studies investigated the phantom movement, showing that it can be functionally disentangled from an imagined movement and very similar to the actual movement of an intact limb. How and to what extent phantom movements and real movements share similar physiological mechanisms? In this EEG study, we focused on a specific aspect of motor control, the motor inhibition, and we asked whether inhibitory motor responses are implemented when a phantom movement has to be suppressed. To this aim, a left upper-limb amputee with phantom movement underwent a Go/Nogo paradigm. During the task, the event-related potentials (ERPs) were recorded. The task was performed with both the (right) intact and the (left) phantom hand, either in real or in imagined conditions. Sixteen healthy controls performed the same task. The results showed that, in response to *nogo* stimuli, the phantom-movement case presented the classical ERP pattern associated to response inhibition, with a large P300 component when the movements of both (right) intact and (left) phantom limbs have to be suppressed. Furthermore, as in healthy controls, the P300 amplitude was greater during "real" than imagined movements with the phantom limb. Single-subject analysis (Crawford's test) showed that, in the phantom-movement case, this inhibitory motor response was not different from that found in healthy controls, actually performing the Go/Nogo task with an existing hand (Real condition), but, crucially, it was significantly different from the Imagery condition of controls ($p < 0.01$). Taken together, these findings provide the first evidence that phantom movements share the same neurophysiological correlates of real movements, not only when an action has to be executed, but also when it should be inhibited.

Body awareness and multisensory integration in a visuo-tactile ERP paradigma

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SAMBA – SpAtial, Motor & Bodily Awareness – Research Group, Psychology Department, University of Turin, Turin, Italy

Multisensory integration of visual and tactile stimuli, simultaneously presented in the same spatial location, facilitate the tactile detection and induce super-additive responses in the neural activity (Visual Enhancement of Touch, VET). Here, we asked whether and how VET is modulated by the sense of body ownership, by comparing conditions in which visual stimuli occurred near to the participant's hand or to another person's hand.
Thirteen healthy subjects underwent a VET paradigm in which event related potentials (ERP) and reaction times (RTs) to tactile stimuli were recorded in two different scenarios, depending on the presence/absence of another person's hand ('With-Alien-Hand'/'Without-Alien-Hand'). In both scenarios, tactile (electrical) stimuli were delivered to the participants' hand, while visual stimuli (colored-led) could appear either near to or far from the stimulated hand. According to the specific scenario, far position could be either close to the alien hand or in an empty portion of the table.
In the ERPs analysis, responses elicited by unimodal visual stimuli (V) was subtracted from those elicited by bimodal visuo-tactile stimuli (VT). The obtain (VT-V) value was compared to the responses elicited by unimodal tactile stimuli (T). The results showed that, in both scenarios, a super-additive response (VT-V>T) in the N2-P3 complex was present only when visual stimuli appeared near to the participant's hand. Crucially, in the P3 component, this super-additive response to the Near condition was greater in the With-Alien-Hand than in the Without-Alien-Hand scenario. Behavioral results on RTs paralleled the ERPs findings.
Taken together, these findings suggest a body ownership dependent modulation of the multisensory integration process. Indeed, the super-additive response to visuo-tactile stimuli on the own hand is selectively boosted by the presence of another person's hand, making an implicit self-other discrimination mechanism more relevant.

Talk session X: Body, space and interaction

Sunday 27th May ***12.00 – 13.00***

Object ownership reveals peripersonal space modulations during observed and executed actions

Ivan Patané [1, 2, 3, 4], *Claudio Brozzoli* [# 1, 3, 4, 5], *Eric Koun* [1, 3, 4], *Francesca Frassinetti* [§ 2], *Alessandro Farnè* [§ 1, 3,4, 6]

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Tactile and visual events occurring on or near our body are integrated in a multisensory representation of the space surrounding us, called peripersonal space (PPS, Rizzolatti et al., 1997). This body centered space is involved in the motor control of goal-directed actions, inasmuch as grasping objects triggers online modulations of PPS (Brozzoli et al., 2009). As acting upon one's own or somebody else's object has been reported to alter movement kinematics (Constable et al., 2011), here we tested whether the concept of object ownership may differentially modulate PPS when acting or merely observing another person acting on a personal property. To this aim, dyads of participants took turns to grasp an object, whose attributed ownership was manipulated in two experiments. To assess PPS, visuo-tactile interactions were probed either before or at movement onset by a task known to modulate tactile perception on the acting hand. Stronger interaction between touches on the grasping hand and visual distractors from the target object served as a proxy of PPS extension (Brozzoli et al., 2009). Importantly, visuo-tactile stimulation was also delivered during observation of grasping actions: prior to or at the onset of an action performed by the participant sitting in front. When ownership was equally shared by the two participants (Exp1), similar PPS extensions arose, regardless of whether action toward the owned object was executed or observed. When examining individual personal property (Exp2), PPS was dynamically extended only when grasping one's own object. Mirroring such an effect, similar PPS changes emerged when observing the other acting on his/her own property. These findings show that even minimally attributed ownership is critical in shaping everyday sensorimotor and social interactions, thus revealing how deeply property can impact on social human behavior.

The role of white matter disconnections in Anosognosia for Hemiplegia

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Anosognosia for Hemiplegia (AHP) is a disturbance in motor awareness, secondary to right brain hemisphere damage, in which patients are unaware of their limb paralysis (Babinski 1914). Decades of neuropsychological and neuroimaging studies revealed that AHP is unrelated to other co-occurring symptoms, such as neglect and memory impairments (Fotopoulou, 2014). Rather, some experimental evidences address AHP to the disruption of action monitoring (Berti et al., 2005) or error recognition processes (Moro et al., 2015). Others hypothesized an impairment in updating one's beliefs about the elf (Fotopoulou, 2008) that involves the failure of motivational/emotional (Vuilleumiere, 2004) and mnemonic (Mograbi & Morris, 2013) processes. Findings from lesion-based symptom-mapping studies revealed the multifaceted nature of the disease, by linking AHP to contradictory patterns of cortical areas. These inconsistencies are due to small sample sizes in most of these studies and to the lack of consideration of lesions remote effects that impact structurally connected circuits. We explored the probability of white matter disconnections in 174 patients (95 AHP patients), through an advanced lesion analysis software (Foulon et al.,2017), excluding clinical variables (motor impairment, lesion size, interval from lesion onset) and associated neuropsychological deficits of AHP (extra-personal and personal neglect, memory impairment). Our results indicated that AHP symptoms may be attributable to the disconnection of indirectly impaired areas. The involvement of three neural systems emerged: the limbic system, the pre-motor loop and the ventral non spatial-attention network. The disconnection of the limbic system, probably plays a role in the failure of updating the autobiographical representations of the self; the disconnection of some pre-motor loop structures contributes to the deficit in monitoring and error processing, and the ventral non-motor attention network disconnection is involved in the attention shifting from the self to the third person perspective. Together, these three systems contribute to awareness of motor deficits.

Reciprocal exchanges of social cues in social interactions

Anna Strasser
Humboldt-Universität zu Berlin, Berlin School of Mind and Brain

Numerous disciplines study the nature of human interactions for which social cognition is required. But up to now there is no canonical definition of 'social cognition'. It is not clear what makes social cognition 'social'. In this paper, I explore the genuinely social relations agents have while applying social cognition in interactions. By focusing on the reciprocal exchange of social information transferred by gestures, mimic or prosody, I elaborate the relation of social reciprocity which can be used to distinguish social from non-social interactions. To illustrate the fact that social reciprocity constitutes an important feature of social interactions, one can consider, for example, a dialog. Entertaining a dialog is an intentional activity in which two social agents are involved by jointly attending to a topic, taking mutual turns, and flexibly encoding their messages based on what they think the listener can understand. It is obvious that a face-to-face conversation cannot be described as a set of one-way relations from sender to recipient. We observe quite complex paths of going back and forth – a variety of social reciprocity. In addition to explicitly linguistic information, many implicitly processed social cues are transported by prosody, bodily gestures and facial expressions and offer a wealth of information. I argue that social reciprocity relies on a wealth of implicit and explicit motor actions which thereby essentially contribute to successful social cognition.

MeeTo

From moving bodies to interactive minds

Friday 25th – Sunday 27th May 2018

Aula Magna del Rettorato, Università degli Studi di Torino, via Verdi, 8 - Torino

Posters

Poster Session I

Friday 25th May ***11.00 – 12.00***

Individuals with long blindness duration "visualize" space through time

Maria Bianca Amadeo[1,2] , Claudio Campus[1], Monica Gori[1]

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Almost one hundred years ago, Jean Piaget argued that "Space is a still of time, while time is space in motion" (Piaget 1927, p.2), suggesting that temporal metric is strictly related to spatial metric. Supporting this theory, we have recently shown that early blind individuals use temporal information to infer spatial environmental coordinates (Gori et al. 2017). In sighted people, metric representation of sounds in space elicits an early occipital response which mimics the visual C1. The same response is not elicited by the sound spatial position in early blind people, for whom it is elicited instead by the virtual position of the sound determined by its temporal delay. Since it is debated how acquired blindness impacts on neural circuits associated with spatial estimation, here we investigate whether temporal information influences spatial representation and the early occipital response in late blind participants.

EEG was recorded in 12 late blind subjects while performing a spatial bisection task in which coherent and conflicting spatial and temporal information was presented. Participants judged whether the second sound was spatially farther from the first or the third sound, while temporal delays were manipulated together with space distances in order to evaluate the role of temporal cues on spatial performance. Results highlight that temporal cues elicit early occipital responses mimicking spatial cues in participants with long blindness duration. Contrarily, individuals with short blindness duration show the early occipital activation in response to spatial and not temporal cues, similarly to sighted people.

Our data reveal a key role of blindness duration, suggesting that the prolonged absence of vision might drive to use temporal instead of spatial coordinates for the construction of multi-sensory maps projected on the retinotopic maps of the visual cortex.

Planning time taken by pairs and individual for a task distribution is differently affected by ambiguity in the coordination cues and ambiguity in the task

Jennifer Ang, Natalie Sebanz, Guenther Knoblich
Department of Cognitive Science, Central European University

Previous research on joint action and cooperation has highlighted the fact that humans are usually keen on achieving a fair distribution of effort, resources, and rewards. However, an open question is what the cognitive processes are that enable joint action partners to achieve a fair task distribution despite the added coordination constraints that joint action poses as compared to individual action. In the present study we addressed two such factors: 1) whether the task to be distributed was clearly defined or whether it could be performed in different ways and b) whether a certain task distribution was implied in the sequence of responses to be performed or not.

Provided with a preview of an eight-item sequence to be later responded to, participants were asked to plan how they would distribute the items in the sequence such that each player responded as quickly as possible and equally often. When items in the sequence were ambiguous in relation to the key mappings of the response buttons, the task could be performed in different ways. Compared to when the task was clearly defined, both pairs and individuals took a longer planning time, with pairs taking significantly longer than individuals. When the task distribution implied in the sequence was ambiguous, while both groups also took a longer planning time as compared to when a certain task distribution was implied, pairs were no significantly different from individuals who distributed the task between their two hands. Additionally, in both experiments, pairs particularly, generally seem to converge on turn-taking or minimal coordination as a strategy.

Altogether, these results suggest that when the task is ambiguous, participants find it difficult and take a longer time to plan. Pairs also appear more reliant on the general heuristics of turn-taking and minimal coordination to successfully complete a fair task distribution.

Does the social situation affect how we process feedback about our actions?

Artur Czeszumski[1,] Basil Wahn[1,2+], and Peter König[1,3]*

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People performing joint actions may cooperate or compete to achieve their joint or individual goals. In the present study, we investigated the neural processes underpinning error and monetary rewards processing in such situations using EEG. We analyzed event-related potentials (ERPs) triggered by feedback about individual and joint actions in cooperative and competitive situations.

Twenty pairs (N=40) of participants performed a joint four-alternative forced choice (4AFC) visual task either cooperatively or competitively (factor social situation). At the end of each trial, participants received visual performance feedback and monetary rewards. Specifically, the feedback included individual and joint errors. Furthermore, the resulting positive, negative or neutral monetary rewards were dependent on the social situation.

A threshold free cluster analysis of EEG data revealed two significant clusters. We found that there is a main effect of the valence of the outcome from 209 to 246 milliseconds after the feedback presentation (median p value: $p = .0004$, minimum p value: $p = .0002$) at midline frontal electrodes. This cluster (FRN) was more negative for losses than wins in both social situations. Moreover, we found that there is a main effect of the social situation from 105 to 148 milliseconds after the feedback presentation (median p value: $p = .0004$, minimum p value: $p = .0002$) at centro-temporal (left) electrodes. This cluster was more positive for the competitive than for the cooperative situation.

In sum, our results replicate previous studies about FRN and extend them by comparing neurophysiological responses to positive and negative outcomes in a competitive situation, which simultaneously engage two participants. Moreover, our results show that human first process the information about the social situation and then evaluate the outcome.

The effect of mechanical coupling on interpersonal coordination in crew rowing

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Although most research on interpersonal coordination focuses on perceptual forms of interaction,many interpersonal tasks, such as crew rowing, also involve interactions of mechanical nature. Thereis no way to escape from such mechanical influences, as agents physically move each other. As such,the stringent nature of the mechanical coupling might stabilize coordination, but may also act as a perturbing source, hindering agents in their own movements and in return the coordination of the dyad. From coordination dynamics, we know that antiphase is less stable than in-phase coordination and that the stability of both patterns, but antiphase in particular, decreases with an increase in movement frequency, which may eventually yield transitions from anti- to in-phase coordination. To investigate the effect of mechanical coupling on the stability of interpersonal coordination, we examined 16 pairs rowing in in- and antiphase at 20 and 30 strokes per minute on ergometers on 'slides' (allowing the ergometer to move with respect to the ground). The ergometers were placed behind each other and could either move independently (no mechanical coupling) or were physically connected (mechanical coupling). Kinematics of handles, rowers and ergometer were recorded at 150 Hz. Seven pairs showed transitions from anti- to in-phase, although the occurrences thereof were not affected by coupling. No transitions from in- to antiphase occurred. For the pairs that did not show transitions, for both interpersonal coordination patterns the variability of relative phase was lower when the pair was mechanically coupled, indicating that mechanical coupling indeed stabilized coordination.

The role of semantic processing in the joint memory effect

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Performing tasks together with others affects the way information is encoded in memory. People encode information relevant to themselves or to a task partner more deeply than non-relevant items (joint memory effect – JME). Investigating the role of semantic processing, we tested the JME in a context where the items' relevance was determined by a surface feature rather than semantic category. If a partner's items are encoded even if the partner's task does not involve semantic processing, a JME should occur.

Each participant in a pair was instructed to respond to words of a particular color, leaving one color unassigned. The words consisted of animal, plant and object names evenly spread over the three colors. In a subsequent surprise memory test we assessed free recall, recognition and source memory performance (where the task was to indicate who had to react to a given word: self, partner, no-one).

Participants recalled more items from their own subset than the other two, and were more likely to correctly recognize self items as "old", than both the partner's and the neutral items. However, participants showed differential source information encoding beyond the self advantage effect: they were more likely to accurately *identify an item as the partner's* than they identified neutral items. Performance was again best for self items.

These findings suggest that encoding of a task partner's words only occurs if the partner needs to process the meaning of those words. At the same time, a partner's task can improve source memory even when the task does not require semantic processing. Our results demonstrate that different aspects of social memory can be dissociated, with source memory being more sensitive to joint task performance than free recall. Being prompted to recall source information may be more likely to activate episodic memory.

The direction of focus of attention modulates the placebo effect in motor performance

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Motor performance can be positively influenced by cognitive strategies, such as the direction of the focus of attention and the placebo effect. Up-to-now these cognitive functions have been considered separately. In this study, we combine them together in order to investigate for the first time their interaction in modulating the motor outcome. Sixty healthy volunteers were asked to perform abduction movements to press a piston with the index finger as strongly as possible. The attention could be focused either on the movements of the finger (internal focus, IF) or on the movements of the piston (external focus, EF). Participants were randomized in four groups: two placebo groups (Placebo-IF and Placebo-EF) received an inert treatment applied on the finger with verbal information on the positive effects on force; two control groups (Control-IF and Control-EF) received the same treatment with overt information about its inefficacy. Furthermore, the placebo groups were conditioned about the positive effects of the treatment with a surreptitious amplification of a visual feedback signalling the level of force. During the whole procedure, actual force and electromyography from the hand muscles were recorded.
The Placebo-IF group showed higher force levels after the procedure than before, whereas no difference was found for the other groups. Moreover, the Placebo-IF group showed an increase in muscle units recruitment without changing the firing rate.
These findings show for the first time that the placebo effect in motor performance can be enhanced by the internal focus of attention.

Second-order motor planning ability without the cerebellum

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The role of the cerebellum in motor planning is well established in the literature. However, it should be furtherly clarified its contribution to high stages of the motor planning hierarchy, as for example to *second-order motor planning* (1). This can be defined as the ability to modulate the earlier phases of an action as a function of the distant goal (2).

We tested second-order motor planning in a rare case of cerebellar agenesis without any other cortical brain malformations (3). The patient (R.G.) and an age-matched control group were asked to perform two actions, consisting in two consecutive motor acts: to reach a cube and to place it into a container. The first act (*to reach*) was identical in both actions while the second one (*to place*) varied for its difficulty (small/large container). Kinematics of actions was assessed using an optoelectronic system for motion capture analysis (OEP System, BTS Bioengineering - Milan) and the duration of each act was computed for both *large* and *small* conditions. To take into account possible confounders we split the 20 trials of each condition into four bins of 5 trials.

Our data showed that, as the control group, R.G. was able to take into account the distal goal from the very beginning phases of the action. Indeed, R.G. modulated the first act according to the final goal difficulty, and his modulation was greater than the control group's one (*Bin1* p=0.019, *Bin2* p=0.045).

Beyond obvious prudence in interpreting single case Vs. controls experimental design, this result may be considered a compelling evidence that second-order motor planning ability can be preserved even in the absence of cerebellum (4). Our findings might also suggest interesting clinical implications for Autism Spectrum Disorder (ASD). Indeed, previous studies demonstrated second-order motor planning anomalies in children with ASD (5, 6).

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The role of the left inferior frontal gyrus in interpersonal synchrony: a tDCS study

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Synchronized motion requires individuals to anticipate and adapt to one another's action timing. a series of previous studies have shown that players engaged in joint improvisation attain moments of highly synchronized co-confident (CC) motion, in two players act as one; yet the neural mechanisms underlying synchrony is still largely unknown. The left Inferior Frontal Gyrus (lIFG) has been proposed to play a role in the matching of motor plans through the encoding and representation of goals and intentions from observed actions, indicating that it may be crucial in modulating synchrony. To examine this, we employed a dual cathodal - transcranial direct current stimulation (tDCS) protocol in which pairs of participants were simultaneously stimulated while they were playing a joint improvisational game, the Mirror Game (MG). We aimed to assess whether cathodal stimulation to the lIFG will decrease the capability of attaining CC. As opposed to our initial hypothesis, we found that under cathodal stimulation participants (n = 46) had higher rates of CC, compared to sham stimulation. Moreover, the duration of their CC segments was longer, across all rounds. We suggest an alternative neural model for lIFG activation. Accordingly, cathodal stimulation of lIFG resulted in a lower ability to control self-other representation and thereby promoted interpersonal synchrony. Given that previous research has established the importance of synchrony in affecting a range of positive social outcomes (e.g affiliation), future studies should examine the generalizability of these findings to conditions associated with social cognition deficits.

Effects of aging in communicative-pragmatic ability

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Communication is a complex ability characterized by the interplay of many elements such as language, use of gestures and paralinguistic connotation that allows people to communicate effectively in everyday life. Elderly adults, even when healthy, may exhibit a reduction in the ability to communicate efficiently, due to a generalised cognitive decline that can characterise old age (Zanini et al., 2005, Aphasiology, 12, 1107-1133). Aim of this study is to provide preliminary results concerning a wide assessment of communicative-pragmatic ability in a sample of 30 healthy aging (N = 15: age range 65-75 years; N = 15: age range 76-86 years) and 15 controls (age range 20-40 years) to investigate a possible decline of such ability. We evaluated communicative-pragmatic ability using the Assessment Battery for Communication (Angeleri et al. 2015, Giunti OS) and the main cognitive functions, e.g. working memory, inhibition, Theory of Mind, in order to investigate if and at what extent a decline of such functions may be related to the communicative-pragmatic one. Only subjects with sufficient cognitive and communication skills, as resulting from the achievement of a cut-off score in the Montreal Cognitive Assessment (Nasreddine et al., 2005, J American Geriatrics Society, 53, 695-699) and the Token Test (De Renzi & Vignolo, 1962, Brain: A Journal of Neurology, 85, 665-678) have been included in the sample. The results show a generalized communicative-pragmatic decline in both age groups of elderly, with respect to the control group (CG). The analysis of variance (ANOVA) revealed a main effect (F= 8,667; p=.001) of Group (three level: CG, old adults and senior-old adults) on pragmatic performance at the ABaCo. Correlation analysis shows that ABaCo correlates with age, working memory, inhibition and Theory of Mind.Our results show that the communicative pragmatic-ability seems to be associated with aging process and cognitive functions.

A quantitative evaluation of the transdiagnostic meaning of social cognitive dysfunction

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The impairment of social cognition has been reported, albeit with different levels of severity, in a wide variety of psychiatric and neurological conditions. On the basis of this evidence, social cognitive deficits are now considered as a potential transdiagnostic component. However, the high number of cognitive functions included in this high-level domain, reflected in research investigations focused on one of them at a time, makes difficult to obtain an overall quantitative evaluation of the phenomena. In order to try to overcome this issue, we used a meta-analytical approach to evaluate, for each of the brain areas known to be involved in social cognition, the abundance of diseases that cause structural alterations to it. Brain regions were determined by searching for the term "social cognition" in Neurosynth.org; both the forward inference (domain-related) and reverse inference (domain-specific) maps were used. We devised a voxel-wise parameter named alteration entropy (A-entropy), ranging from 0 to 1. Analyzing the results obtained by applying the anatomical likelihood estimation methodology on the whole international voxel-based morphometry database of BrainMap (1825 experiments, 19325 subjects), we were able to identify the brain areas thought to be vulnerable to a wide (high values of A-entropy) or limited (low values of A-entropy) range of brain diseases. Notably, all the regions analyzed showed a very high A-entropy, with values ranging between 1 in the right insula and 0.7 in the right superior parietal lobule. These results suggest that most of neuropathological conditions can induce structural alterations in the brain areas involved in social cognition; these alterations, in turn, can produce functional impairment in the domain of social cognition. In conclusion, the present work provides quantitative support to the interpretation of social cognitive dysfunction as a clinical sign across a large number of different diagnoses.

Prediction errors during interpersonal motor interactions reveal frontal and occipito-temporal theta.

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Being able to coordinate in time and space with our peers is the keystone to interpersonal interactions and possibly the root of many social functions. Interpersonal interactions involve several functions, from low-level action perception to high-level goal prediction and the accuracy of these predictions foresees the success of joint actions. Indeed, when interacting, the prediction of the partner on-going behaviour is supported by the moment-to-moment integration of visual (i.e. others' movements) and motor (own actions) activity. However, sometimes the behaviour of our partners changes unexpectedly so that our predictions happen to be wrong thus requiring the ability to detect and react to these prediction errors. In the present study (n=22) we investigated whether EEG motor-error-related time- (ERN/Pe) and time-frequency (Theta/Alpha modulations) neuromarkers also emerge when synchronizing with a virtual partner performing motor errors in a joint reach-to-grasp task. The task included two conditions, namely: i) a Cued condition, requiring participants to adapt only the timing of their movements in order to synchronize with the virtual partner (participants knowing in advance *where* they have to grasp) and, ii) an Interactive condition, requiring participants to adapt in time and space (with the need to synchronize and select their action according to the avatar's movement). Critically, in 30% of the trials, the avatar performed a motor error by switching from a reaching site to another (Correction condition). First, we describe the EEG correlates of error detection during an interaction with a virtual partner performing motor errors. Second, we show that these markers are triggered by the necessity to predict other's actions (Interactive condition). Finally, the source estimates of the Theta frequency markers highlighted the recruitment of fronto-central and occipito-temporal regions, indicating a possible role for these regions in processing visual and motor information during social interactions.

Functional role of occipito-temporal Theta rhythm in Hand visual perception.

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Body and body parts visual perception represents the initial step for higher-order social functions such as the ability to understand others' actions and interact efficiently with them. Imaging and EEG studies have shown that the passive perception of the full body and of specific body parts is associated with: 1) activity of an occipito-temporal region, the Extrastriate Body Area (EBA) (Downing et al., 2001), 2) a modulations of a specific ERP component (N190, Thierry et al., 2006), and 3) a Theta-band (4-7Hz) synchronization recorded from occipito-temporal electrodes compatible with the location of EBA (Moreau et al., 2017). To characterize the Theta-band role in the processing of body-part stimuli over occipito-temporal electrodes, we recorded EEG data in 24 participants who were engaged in an identification task (Match-to-Sample) of hands and non-body control images (i.e. leaves) that were presented for 1s at individual contrast threshold. Besides confirming that occipito-temporal electrodes show a larger N190 for hand images compared to control stimuli, cluster based analysis revealed a right occipito-temporal cluster showing an increased Theta power when hands (compared to leaves) were presented. Moreover, the same cluster showed stronger Theta power correctly recognized hands compared to not recognized ones, while no such difference was revealed for the control stimuli. As well as replicating a modulation of the Theta band in visual perception of body-parts (i.e. hands), our results reveal that Theta activity is influenced by the recognition process. Interestingly, whole-brain functional connectivity measures (PLV) reveal a stronger theta-band connection between the right occipito-temporal cluster and bilateral sensorimotor and left premotor clusters for hands compared to control images. Theta modulation over occipito-temporal sites associated with body-parts visual processing might play a role in perceptual processes facilitating social interactions and action recognition.

Action expectations modulate joint attention in naturalistic scenarios

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Predictive processing is fundamental for social cognition. Social signals, such as gaze direction, provide valuable information to generate expectations regarding others' behavior and mental states. However, the link between prediction of action sequences and following of gaze direction in complex social situations remains unexplored. We investigated how high-level expectations concerning others' action goals influence gaze following. Our paradigm consisted of a gaze-cueing procedure embedded in an action sequence composed of naturalistic photographs. In a series of studies we examined how attention is guided by the observed gaze direction, and the background expectations regarding the action context. Three experiments were screen-based, and one study implemented the paradigm in a realistic interaction with an embodied humanoid robot iCub. Behavioral results showed (a) faster target discrimination responses to targets validly cued by gaze, relative to invalidly cued locations (the gaze cueing effect, GCE); and (b) modulation of the GCE by action expectations. The latter was observed in the form of enhanced GCE when the actor gazed at objects congruent, rather than incongruent or neutral, with respect to the action context. Eye tracking showed that this pattern was due to covert, rather than overt, attentional orienting. EEG results showed that gaze validity and participants' expectations modulated the target-related N1 ERP component. We also found modulation of gaze-locked ERP components related to congruency of gaze with respect to action context. Collectively, our findings suggest that expectations regarding others' behavior modulate gaze following in naturalistic scenarios. This is in line with the idea that humans use various social signals to predict events in the environment. Violation of those predictions influences low-level mechanisms of attention and perception.

The role of movement frequency on motor contagion

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When required to execute an action whilst simultaneously observing an incongruent action, individuals' movements are more variable in the direction of the observed action than when observing a congruent action (for a review see Blakemore and Frith, 2005). It has been demonstrated that this 'motor contagion' is tuned to the properties of the observed movement (e.g., being greater for movements with smooth and bell shaped rather than constant velocity profile) (Bisio et al., 2014; Jansson et al., 2007). So far, no study has investigated whether motor contagion is sensitive to the frequency of the observed movement. Here we asked 12 adult participants to execute either horizontal or vertical arm sinusoidal movements while observing a model performing either a congruent (i.e., same direction as the participant) or an incongruent (i.e., orthogonal direction with respect to the participant) movement. Crucially, the model was trained to move at one of three different frequencies: 0.5, 1, and 1.6 Hz. Movements were recorded using a near-infrared camera motion capture system (Vicon System). Movement variability (mm), defined as standard deviation within the error plane (i.e., orthogonally to the plane of the instructed movement), was used as dependent measure. Motor contagion was operationalized as an increase in movement variability within the error plane during the observation of incongruent compared to congruent movements. Results indicated that whereas observing movements at lower frequency (i.e., 0.5 Hz) lead to an increase of the overall variability, movement frequency had no influence on motor contagion. These findings suggest that motor contagion may be independent of the frequency of observed movements.

Perceiving objects through actions: real grasps prime the presence of an object

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Previous studies demonstrated that action perception impacts on object recognition (Helbig et al. 2006, 2010; Kiefer et al. 2011). For instance, participants are more accurate in naming a target object when it is preceded by a movie showing a hand in interaction with a similar object than when it is preceded by a movie showing a hand in interaction with a different object. To date it has not been tested whether the observation of a hand approaching an object can prime object perception. We asked participants to observe video clips showing real (i.e., a hand grasping a present object on a target location) or pantomimed (i.e., a hand pretending to grasp the very same object as in real grasps imagined on a target location) grasps. To prevent participants' vision of the object (present or absent) a spatial occlusion was superimposed at the target location. After each video clip, used as action prime, one of two target stimuli could be presented. One target stimulus, namely *object-present*, consisted of an image showing the grasped object at the target location. The other target stimulus, namely *object-absent*, consisted of an image showing no-object at the target location. Participants had to detect if the object was present or absent in the target stimulus. Responses were given by pressing one of two keys on a keyboard. Reaction times revealed that participants were faster to respond to *object-present* target stimulus when it was preceded by real action primes than when it was preceded by pantomimed action primes. No similar effect was present on the *object-absent* target stimulus. These results show that real -and not pantomimed- grasps prompt the presence of the object the hand is going to interact with.

How you will move affects me: the co-representation of the other's upcoming movements

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Our actions occur hardly ever in a lonely environment. Most of the times, we act jointly with other people. We walk, work or play games together.

The variety of mechanisms involved in joint actions such as these have led researchers to propose the "co-representation hypothesis"[1]: when an agent performs a task with another person, he represents not only his own portion of the task, but also that of his partner, and this second-type representation appears to interfere with motor performance[2].

However, the way and the extent to which the representation of the other's task demands is integrated within one's own motor system is still a matter of debate.

In the present study, we aimed at investigating the co-representation hypothesis through the characterization of movement kinematics. Participants, arranged in pairs, performed a sequential joint task where they had to move a pawn towards different targets. While the first agent's task was kept constant throughout the entire experiment, the actions of the second agent varied in difficulty depending on the size and the position of the target. We recorded movement kinematics form both participants.

Results show that the kinematics of the first agent were influenced by the action that his partner would have performed immediately after. Moreover, this effect seems to be movement-specific, suggesting that the first agent was not simply representing the difficulty of the task that the other agent was about to perform, but also that he was representing the specific kinematic profile that the other was going to carry out.

These results are in line with the co-representation hypothesis, enriching it with the finding that people co-represent not only *what* their partner is about to do, but especially *how* he will do it, in a *motor* equivalent way.

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Co-actors represent the order of each other's actions

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Previous research has shown that people represent each other's tasks and actions when acting together. However, less is known about how co-actors represent each other's action sequences. Here, we asked whether co-actors represent the order of each other's actions within an action sequence, or whether they merely represent the intended end state of a joint action together with their own contribution. In the present study, two co-actors concurrently performed action sequences composed of two actions. We predicted that if co-actors represent the order of each other's actions, they should experience interference when the order of their actions differs. Supporting this prediction, the results of six experiments consistently showed that co-actors moved more slowly when performing the same actions in a different order compared to performing the same actions in the same order. In line with findings from bimanual movement tasks, our results indicate that interference can arise due to differences in movement parameters and due to differences in the perceptual characteristics of movement goals. The present findings extend previous research on co-representation, providing evidence that people represent not only the elements of another's task, but also their temporal structure.

The role of movement kinematics in neural chain selection during action observation.

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The ability of understanding the intentions of others is of crucial importance for humans. Recent proposals attribute this ability to the linking together of overlapping segments during action observation, sometimes termed *motor chaining*. The proposed mechanism is rather simple: any time a motor chain is activated (e.g., grasp-to-drink), the observer attributes the corresponding intention to the agent (e.g., to drinking). However, the mechanisms by which a specific chain is selected remains poorly understood. The current study investigated the possibility that, in the absence of discriminative contextual cues, slight kinematic variations in the observed grasp inform the mapping to the most probable chain. Chaining of motor acts predicts that in a sequential grasping sequence (e.g., grasp-to-drink), electromyographic (EMG) components that are required for the final act (e.g., mouth-opening mylohyoid muscle, MH) show anticipatory activation. To test this prediction, in two experiments combining EMG, Transcranial Magnetic Stimulation (TMS) and predictive models of movement kinematics, we measured the level and timing of MH activation during the execution (Experiment 1) and observation (Experiment 2) of grasping sequences (grasp-to-drink vs. grasp-to-pour). We found that cortico-bulbar excitability during grasping observation varied as a function of the kinematics of the observed grasp, activity in MH being greater for the observation of grasp-to-drink compared to grasp-to-pour movements. These results are the first to show that subtle changes in movement kinematics drive the selection of the most probable motor chain linking the observed act to the agent's intention.

Rational joint action planning: People make decisions that maximize co-efficiency

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In joint object manipulation tasks, people often make efforts to reduce their partner's discomfort. One explanation for such a behavior is that people aim to share their partner's efforts to minimize aggregate costs of the joint action (maximizing co-efficiency). This would constitute a rational movement planning strategy for interpersonal coordination, given a shared goal. Alternatively, people may only aim to altruistically reduce their partner's effort, regardless of considerations of joint costs (increasing their partner's individual efficiency). In the present study, we contrasted these two accounts. We used a dyadic motor coordination task, in which participants transported an object to a goal area together via one of two potential paths. The costs of the available movement options, operationalized in terms of path lengths, were systematically manipulated. The choices of the participant who initiated the joint action suggested that, when the action could be executed in less and more co-efficient ways, decisions were based on aggregate costs that maximized the dyad's overall efficiency, even at the expense of compromising individual efficiency. When movement options were equalized in terms of aggregate costs, participants tended to take over some effort from their partner. While this latter result indicates the operation of altruistic tendencies, our overall findings support the proposal that the planning in sequential joint actions is based on rational decision-making via calculating and minimizing joint costs of the actors.

Electroencephalographic time-frequency patterns of braking and acceleration movement preparation in car driving simulation

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The objective of the present work was to identify electroencephalographic (EEG) components in order to distinguish between braking and accelerating intention in simulated car driving. To do so, we collected high-density EEG data from twenty participants while they were driving in a car simulator. The EEG was separated into independent components that were clustered across participants according to their scalp map topographies. For each component, time-frequency reactivity related to braking and acceleration events was determined through wavelet analysis, and the cortical generators were estimated through minimum norm source localisation. Comparisons of the time-frequency patterns of power and phase activations revealed that theta power synchronisation distinguishes braking from acceleration events 800 ms before the action and that phase-locked activity increases for braking 800 ms before foot movement in the same frequency range. In addition, source reconstruction showed that the dorso-mesial part of the premotor cortex plays a key role in preparation for foot movement. Overall, the results illustrate that dorso-mesial premotor areas are involved in movement preparation while driving and that low-frequency EEG rhythms could be exploited to predict drivers' intention to brake or accelerate. Further research is needed to assess the predictive capabilities of such EEG features for online applications.

Knowing Others' Minds: Automatic Level -2 Visual Perspective Taking as a Perceptual Simulation

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Effective social interactions rely heavily on our ability to know the minds of others; it stands to reason that it would be of benefit to understand the world from their point of view. One way of doing this it to simulate their visual perspective (VP). There is growing evidence that we sometimes automatically compute the VP of another person, however much of the existing literature highlights the automaticity of computing *what* is seen by others, rather than *how* it is seen. Here we present evidence for a perceptual simulation account of level 2 visual perspective taking (VPT-2), and moreover provide evidence that VPT-2 occurs automatically. Participants were asked to identify whether an item (a letter or a number) appearing on a table pictured on a screen in front of them was presented normally, or in its mirror image. These items appeared to rotate on the table, with each trial picturing items in one of eight possible orientations relative to the participant. In 50% of trials, a person was visible in the scene, positioned at the table 135° to the left or right of the participant. Reaction times (RTs) were found to speed up significantly in trials wherein items pictured on the table were oriented towards the human on the screen, relative to trials picturing the table alone. In a follow-up study, we substituted the people for an object. Using a between subjects design to eliminate carryover effects, we compared the interference effect for humans vs. objects, and found that those in the human condition followed the same response pattern as those in the original study, whilst those in the object condition did not. This shows that humans are specifically sensitive to the conflicting VPs of humans, and that VPT-2 occurs automatically in the form of a perceptual simulation.

Interpersonal Synchrony and Person-Specific Theory of Mind

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Prior research suggests that interpersonal synchrony has positive consequences for affiliative emotions (liking, empathy), cognitions (perceived similarity), and behaviours (helping). The current research investigated whether such effects might be attributable the effect of synchrony on theory of mind (ToM) processes. We hypothesized that motor synchrony would facilitate ToM processes, and that it would do so in a person-specific fashion. Groups of three participants were seated around a table and listened to music through headphones connected to the same device via an audio splitter. Two of the three participants were instructed to tap their hands in time with the music they heard, whilst the third participant listened and observed, but did not tap. In one experimental condition, participants heard the same music, and hence the hand-tapping was synchronized. In a second condition, the two tappers heard slightly different versions of the music, resulting in asynchronous tapping. Participants then completed two blocks of a computerised 'Director' task, ostensibly one with each of the other two participants. In the Director task, participants received instructions from a director about how to move objects around a shelf that was positioned between them. Some objects were visible only to the participant, and hence correctly following the instructions required them to consider what the director could see. Accuracy and response time were recorded. Results indicated that participants who had tapped in synchrony were more accurate (and faster to be accurate) in following instructions from each other than from the observer (who was neither synchronous nor non-synchronous). In contrast, participants who had tapped asynchronously were more error-prone (and slower when they did make correct responses) in following instructions from each other, compared to from the observer. These results suggest that motor synchrony facilitates the application of one's ToM, but only to the specific individual(s) with whom one synchronized.

Poster Session II

Saturday 26th May ***11.00 – 12.00***

Auditory spatial representation around the body

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Vision seems to have a pivotal role in developing spatial cognition. A recent approach, based on sensory calibration, has highlighted the role of vision in calibrating hearing in spatial tasks. It was shown that blind individuals have specific impairments during audio spatial bisection tasks. Vision is available only in the frontal space, leading to a "natural" blindness in the back. If vision is important for audio space calibration, then the auditory frontal space should be better represented than the back auditory space. In this study, we investigated this point by comparing frontal and back audio spatial metric representations. We measured precision in the spatial bisection task, for which vision seems to be fundamental to calibrate audition, in twelve sighted subjects. Two control tasks, a minimum audible angle and a temporal bisection were employed in order to evaluate auditory precision in the different regions considered. While no differences were observed between frontal and back space in the MAA and temporal bisection task, a significant difference was found in the spatial bisection task, where subjects performed better in the frontal space. Our results are in agreement with the idea that vision is important in developing auditory spatial metric representation in sighted individuals.

Pointing performed by others facilitate visuo-spatial memory, but how much should I be involved?

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Several previous studies have investigated how the production of movements influences visuo-spatial working memory. Specifically, it has been shown that self-performed pointing movements facilitated the recognition of spatial arrays in a visuo-spatial working memory task. In the present experiments we examined the effects on memory of pointing movements that were either self-performed or performed by others. Participants were administered a task that required the maintenance of two consecutive arrays of three or four items, one encoded only by visual observation, the other by visual observation accompanied by pointing movements (performed either by the participant or by the experimenter). In three experiments, the percentage of trials involving self-performed pointing movements was varied from 50% (Exp. 1), to 16.66% (Exp. 2), to 0% (Expt 3). We found that experimenter-performed movements facilitated array recognition only if alternated with self-performed movements. The positive effect of pointing remained significant even when the frequency of self- performed movements was restricted to 16.66% (1/6 of the total number of trials). These results suggest that other-performed movements can improve visuo-spatial working memory performance, as long as they are alternated with self-performed movements. We propose that this benefit reflected either motor simulation or richness of encoding.

The role of gaze in social requests

Sonia Betti, Umberto Castiello, Umberto Granziol, Silvia Guerra, Giovanni Zani and Luisa Sartori

Università degli Studi di Padova

Observing eye gaze and body movements provides a relevant source of information for social interaction. This study investigated whether observing other's gaze – pointing toward an object – affects motor responses in onlookers. By using transcranial magnetic stimulation (TMS) on primary motor cortex, we assessed corticospinal excitability while participants observed actions sequences eliciting or not interactive responses. Results showed an inhibitory pattern in observers' muscles when an actor's gaze and request gesture were concurrently pointing to the salient object. This motor pattern was positively correlated with the 'willingness to interact', as reported by participants in a following questionnaire. In particular, the higher was the tendency to interact, the higher was the inhibitory pattern of activity in the muscle required to interact with the actor. Overall, these data seem to indicate that the joint contribution of gaze and request gesture increases participants' proactivity, so that muscular inhibition is needed to prevent unwanted overt reactions.

Social status shapes affective evaluations and dyadic motor interactions in humans.

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Interpersonal behaviours in human societies are deeply influenced by the hierarchical position (e.g. status) each agent occupies. Previous findings suggest that social status modulates different aspects of social cognition (e.g. attention, imitation and action perception). However, little is known about whether social status influences online dyadic motor interactions. In a first behavioural experiment (N = 26), we tested the effectiveness of a new status-inducing procedure (i.e. an interactive game with two fake players). Players' status was induced by manipulating the achieved scores of the two fake players so that one of them would rank first (high status) and the other would rank last (low status). Before and after the manipulation we measured participant's implicit affective evaluation of the two players with a modified version of the Affective Misattribution Procedure (AMP) and collected explicit ratings of the two players' attractiveness, competence, intelligence and dominance after the manipulation. Testifying the effectiveness of our manipulation, we found a decrease from the first to the second AMP session associated to the low status player which was also rated as less competent and intelligent than the high status one. In a second kinematic experiment, we tested the effects of social status on motor interactions by asking participants to synchronize with the two players (in a within-subjects design) to perform imitative or complementary reach-to grasp movements. Preliminary results indicate that, only during complementary actions, participants achieved a better performance when interacting with the low status player compared to the high one suggesting that hierarchical status plays a role in interpersonal coordination.

I see the way, but only when its expression is typical: motor representation of vitality forms in autism

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We (motorically) focus not only on what others do and why, but also on how such an action is performed (e.g., gently/rudely). This ability to encode the motor style of an action, namely vitality forms (VFs) (1), gained interest in light of its putative mirror properties and its implications in autism (ASD) (2, 3). ASD children, indeed, show deficit in VFs recognition (4) of actions performed by typically developed (TD) adults. Benefiting also from our preliminary findings, we aimed to test the possibility that this deficit may be due to anomalies in VFs motor representation. Thus, we investigated if TD adults could have difficulties to recognized VFs performed by ASD children. A TD adults sample (N=40) observed video-clips showing ASD and TD "actors" performing two actions with two different VFs. In Exp1, participants (N=20) were requested to judge the VF (HOW task) and the performed action (WHAT task). In Exp2 the procedure was the same, but participants (N=20) had to judge the velocity instead of the VF. Both accuracy and reaction times (RTs) were acquired. Stimuli were extracted by motion capture system recording (SMART, BTS – Milan). In Exp1, the main result is that TD adults were less accurate in judging VFs performed by ASD actors (ANOVA interaction: $p=0.012$). Moreover, in the HOW task they were slower to answer to ASD actors' video-clips ($p<0.001$). In Exp2, testing both accuracy and RTs, we ruled out the hypothesis that participants based their answers on a specific kinematic parameter (i.e., velocity) instead of VFs. This study offers a further (indirect) confirmation that ASD children encode VFs differently from TD individuals, by showing that TD adults have significantly more difficulties in judging VF performed by ASD compared to TD ones. This sparks intriguing insights into the idea that motor representations in ASD are anomalous (5).

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Does 'me' become 'we'? we-prioritisation in the cognitive system.

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Humans show a robust self-enhancement with reaction time and accuracy. For example, when judging if a shape assigned to represent themselves matches a label (e.g. 'self', 'friend', 'mother', 'stranger') participants are faster and more accurate than when the shape represents another person. We theorized that the cognitive system's self-predilection could extend to a we-predilection via two potential and theoretically dissociable routes: one stemming from identity fusion, and one based upon social identity theory. In the case of identity fusion theory, activating a we-representation should similarly activate the self. Under such co-activation, 'we' should be processed under chronic levels of self-activation which promote attentional orienting mechanisms in relation to the self. Thus, similar levels of self- and we-prioritisation should be observed. Conversely, under social identity theory, we-prioritisation should result due to top-down modulation of relevant stimuli. Consequently, there would still be an observable advantage for we-stimuli over other-stimuli but we-stimuli should not achieve the magnitude of the self-advantage. This is because under social identity theory the social self is considered distinct from the personal self. Across three experiments we systematically manipulated the strength of the group-representation. We-prioritisation emerged across all three experiments but it only achieved a similar magnitude to self-prioritisation in the weakest group manipulation where participants were placed in an arbitrary group and did not share any similarities with their group member. This suggests that under a weak group manipulation 'we' stimuli are processed as self-stimuli because personal agency is retained. Conversely, under the strongest group manipulation the social self is activated separately from the personal self. Thus, we conclude that our results are most consistent with the social identity hypothesis where 'we' is prioritised within the cognitive system via top-down modulation of expectancies for stimuli that are behaviorally relevant.

Entrainment beyond Embodiment

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Our study focused on the phenomenon of "entrainment", the spatial-temporal coordination between a person and an external rhythm and, more crucially for the issue of social interaction, the coordination between two or more persons with such a rhythm (called "interpersonal entrainment"). The latter phenomenon has been shown to occur especially among musicians (playing Indian, classic, jazz music) and in a few studies on non-musicians[1]. In particular, it is not clear if entrainment could occur also in non-musicians (as in musicians) in an alternate joint-tapping task, whereas it has been shown in synchronous joint-tapping[2]. Moreover, we wanted to study whether such a (proto) musical joint-action, that, contrary to previous studies[3], involves a real interaction, could be modulated by the partner's position (allocentric or egocentric) and its physiological counterpart. Single-pulse Transcranial Magnetic Stimulation was delivered to the right primary motor cortex (M1) in order to record the Motor-Evoked Potentials (MEP) from the FDI muscle of the left hand (at rest) during the tapping task (with the right hand), hypothesizing that in a joint-condition MEPs should be higher than in a condition in which the subject taps alone, in accordance with the literature on action observation and mirror neurons. We also expected that manipulating the representation of the shared action by changing the partner's position could change both the behavioral outcome (entrainment) and the physiological outcome (cortical-spinal excitability), as it has been suggested by other studies[4]. In particular, we expected that, while in the allocentric condition MEPs should increase, in the egocentric condition, where an illusion of ownership of the partner's hand could arise, both outcomes should be similar to the condition in which the subject taps alone.

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Improving balance control with the placebo effect

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Different studies show the positive effect of placebo on motor performance. It is still unknown, however, whether the placebo effect can work also in balance control, a very important aspect of human motor functions. The aim of our study was to tackle this issue. Thirty healthy volunteers, randomized in two groups (placebo and control), were asked to perform single leg balance tasks in three sessions. In each session, subjects performed the task (with the dominant leg) for ten trials with the duration of 30 sec and 30 sec interval between the trials. Before the second and final sessions, we applied an inert treatment on the gastrocnemius muscle with different verbal information to the groups. The placebo group was informed about the positive effects of the treatment. Conversely, the control group was informed that it was inert. To evaluate balance control, we defined relative leg angle (RLA) and hip displacement (HD), as measures of the discrepancy between the current position of the leg and the position obtained at the beginning each trial. We defined RLAmax and HDmax as the mean value of maximum RLA and maximum HD of ten trials, respectively. Higher values of RLAmax and HDmax represent less balance control during the task. Additionally, subjective parameters were also collected, like participants' expectation of improvement due to the treatment, perception of treatment efficacy and of stability.

Results showed that in the final session the placebo group had lower levels of HDmax than the control group. Also RLAmax and HDmax in the anterior-posterior direction were lower in the placebo group than the control group. Furthermore, the placebo group perceived to be more stable and perceived the treatment was effective.

For the first time, these findings demonstrate an improvement in human balance control after a placebo procedure.

Shameless! Evidence of amygdala lesion in shame processing

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Amygdala is a key structure in recognizing and responding to social stimuli, in particular fear facial expressions. If on one hand, the role of amygdala in processing of basic emotion has been extensively investigated, on the other, it role in social emotion representation (i.e., emotions that depend on other individual's thoughts or actions, such as shame and guilt) have been less studied. We report the case of patient FF with a bilateral amygdala lesion at the level of basolateral nuclei, as a consequence of the Erdheim-Chester disease. This patient and matched healthy controls were tested for their abilities to identify facial emotions, interactive social situations inducing shame and guilt, and their subjective experience of shame and guilt. Results revealed that FF performed significantly worse than healthy controls in recognizing pictures of fearful and shameful faces while his ability to visually recognize all other emotions was spared. Moreover, FF subjective experience of shame was lower than healthy controls. This pattern of results points to a causal role of the amygdala in processing shame.

Getting to grips with action understanding: Affordance matching predictively shapes the perceptual representation of others' actions.

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Recent models argue that action understanding is a predictive process, where social and contextual (e.g. object) information are used to infer the actor's goal, so that predictions about their upcoming actions can be formed. These models also argue that the predictions are not cognitive, but are represented perceptually. Studies from our lab have shown that prior expectations about a forthcoming action can bias the perception of this action towards this expectation. In these studies, the actor's intentions are announced and predictions are made explicitly, before the onset of the action. However, emerging evidence suggests that action goals and intentions can also be identified and updated during the ongoing action, by monitoring any match between the unfolding action kinematics and the potential target objects. Here we show that perception of an upcoming action can be biased in the direction of the expectation when predictions are made implicitly, and when predictions are made on-line, once the action has already commenced. Participants watched an actor reach towards a large object and a small object forming either a whole hand power grip or a precision grip. During its course, the hand disappeared, and participants made perceptual judgements about the last seen position on a touch screen. Judgements were consistently biased in line with action expectations, such that power grips were perceived closer to large objects and precision grips were perceived closer to small objects. This provides evidence, for the first time, that people make on-line adjustments of predicted actions based on the match between hand grip and object goals, resulting in a distorted perception of this action. These results reveal that our perceptual experience of others' actions is derived from an integration of incoming bottom-up sensory information and top-down expectations of the action.

The neural oscillatory markers of phonetic convergence during verbal interaction

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During a conversation, neural processing of speech production and speech perception in both speakers temporally overlap and is continuously modulated in real time, based on conversation dynamics, context, expectations, and quality of the interaction. Recently, a growing interest in the neural dynamics underlying interactive tasks, in particular in the language domain, has mainly tackled the temporal aspects of turn-taking in dialogues. Beside temporal coordination, an under-investigated phenomenon is the neural correlate of implicit convergence towards a shared phonetic space. Here, we used dual electroencephalography (dual-EEG) to record brain signals from subjects involved in a relatively constrained interactive task where they were asked to take turns in chaining words according to a phonetic rhyming rule. We quantified participants' initial phonetic fingerprints and tracked their convergence during the interaction via a robust and automatic speaker verification technique. Results show that phonetic convergence is characterized by a left anterior alpha/low-beta desynchronization in the speech motor preparation phase and by high beta suppression before and during listening to speech in right central and left frontal sectors, respectively. With this work, we provide evidence that during turn-taking verbal interaction, alpha and beta oscillatory dynamics are linked to the coordination of the "how" rather than the "when" interaction takes place. We suggest therefore that speech-based interaction, besides affecting the temporal pattern of turn-taking, leads to a critical change in speech phonetic targets. These changes in how we generate the speech output, are reflected in specific preparatory neural markers demonstrating that during a conversation, speech perception and production are highly interdependent and co-constructed by participants.

The intervening relation of "top-down" and "bottom-up"-processes for the generation of human behavior

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Understanding the role of mental states in controlling bodily movements marks an intricate endeavor that is tackled by philosophers and neuroscientists alike. However, each perspective usually points to a different causal process for the explanation of human behavior; i.e. philosophers being rather "top-down"- oriented while neuroscientists rely on "bottom-up"-informed mechanisms. This contrast marks the starting point of our research that aims at understanding the intervening nature of both perspectives by compiling a comprehensive resource on interdisciplinary theories of agency. As such, our project is based on combining philosophical and neuroscientific theories to introduce a multi-level framework that covers the phenomenon of agency on a broad scale, is theoretically reliable, and able to generate input for empirical research. We started with a systematic review of philosophical theories of agency, which was complemented by surveying empirical findings about motor behavior. This approach allowed us to sketch a basic, theoretical framework of agency which is based on types of intentions, i.e. highly dynamic mental states that govern the planning, coordination, and execution of goal-directed movements by exerting high-level control. Efforts to combine philosophical and scientific theories within the last year resulted in several refinements of the framework and revealed an intricate interleaving between "top-down" and "bottom-up" processes within the phenomenon of agency. By advancing our understanding of the interplay between these high-level and low-level processes we were able to identify the so called interface problem as the core issue of interdisciplinary research on human behavior. On this basis we emphasize the importance of "bottom-up"-processes for the constitution of "top-down"-phenomena as well as the careful inclusion of empirical findings and approaches in our framework.

Social Inhibition of Return from the Distance

Orit Nafcha, Simone Shamay-Tsoory, Shai Gabay

Understanding others' actions and intentions is important for successful adaptation to the environment. It has been suggested that when we observe another person's action toward a specific location, an inhibitory process is initiated toward that location. This effect has been termed Social Inhibition of Return (SIOR; Welsh et al., 2005). SIOR refers to slower reaction time (RT) toward a location already searched, whether the search had been done by the individual or by another person. In a new computerized version of the basic paradigm, two participants performed the task together, sitting in front of a computer screen, facing each other. Each participant, in turn, responded to a peripherally presented target in two successive trials. The first trial was performed after the other participant responded and was aimed at examining SIOR. The second trial for each participant was aimed at studying the self-induced IOR. In the current study we aimed to examine whether merely believing that there is a partner would be a sufficient social cue to induce the SIOR effect. Accordingly, we examined two conditions. Under the first condition, participants preformed the task alone. In the second condition, participants were made to believe that they were performing the task with a co-actor, only in separate rooms. At the end of the study participants reported if they believed they were playing with a real person or a computer. Participants who did not believe they were playing with a real partner were excluded. Results demonstrated SIOR even though participants did not directly observe the co-actor's actions. Furthermore, there was no SIOR when the participants performed the task alone, under the same visual display.

Lexical competition between words, the body, and in social interaction

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Objective: To differentiate the effect of compounding demands, both corporal and social, on a cognitive task requiring the retrieval of competing lexical items in speech production.
Methods: Three experimental groups of adults (ages 18-35) were recruited to complete one of three tasks followed by a questionnaire designed to measure emotion contagion. Experiment 1 had participants in a sitting position to complete a picture naming task. The task consisted of 500 test pictures that included groups of visuo-semantic neighbors (e.g., deer, elk, and antelope) that would lead to greater lexical competition as seen in spoken errors and/or reduced reaction times. A signal-to-noise ratio, known as 1/f noise, was calculated from the picture naming reaction times and used as a descriptor of individual differences. In Experiment 2, participants performed the picture naming task while standing. A 1/f noise ratio was calculated for each participants' movement tracked online using a Microsoft Kinect. In Experiment 3 participants performed the picture naming task while standing in the same room as an experimenter that recorded the participants' errors as they were being made.
Results: Spoken errors and slower reaction times increased with task complexity, as did the randomness (i.e., white noise) of the 1/f noise ratio. Participants that experienced less lexical competition, succeeded in maintaining greater periodicity (i.e., pink noise) within their 1/f noise ratio for both picture naming reaction times and bodily movement. Participants more susceptible to emotion contagion, as measured in the questionnaire, were more likely to compound the effect of lexical competition in Experiment 3 due to the presence of the experimenter.
Conclusion: The ability to control cognitive demands lessons as complexity increases due to online maintenance of cognitive, corporal and social cues. Cognitive control can be seen in those participants able to maintain periodicity within their responses to external stimuli.

The influence of cooperative interaction on the processing of auditory action-effects

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Recognizing the causal connection between one's own action and its sensory effect influences both the processing of elicited sensory events and the planning of subsequent movements: In the case of self-induced sounds motor predictions can affect behavioral and electrophysiological measures of auditory processing, while the sounds in turn can be used as feedback to optimize tone-eliciting movements. The current study investigates whether analogous processes can also be observed for tone-eliciting actions performed by a co-actor in a joint action task.

Two participants performed similar actions (tapping on a force sensitive resistor) simultaneously. According to the standard action-related ERP attenuation paradigm, participants completed three conditions: In the motor-auditory condition actions elicited sine tones. In the motor condition actions had no auditory effects. In the auditory condition no actions were required, participants only listened to a replay of the tone-sequence generated in the motor-auditory condition. The level of cooperation was manipulated between the first and second part of the experiment. In the cooperative part participants were instructed to alternately perform actions, and jointly produce a uniform distribution of between-action-intervals in the 2–6-s time-range. In the parallel part participants concurrently performed independent time interval production tasks. During the experiment event-related potentials elicited by motor and sensory events, as well as force profiles of the actions were recorded. ERP attenuation was determined as the difference between auditory ERPs (N1 and P2 amplitudes) recorded in the auditory and motor-auditory (motor corrected) conditions.

ERP attenuation for sounds elicited by observed actions, and force development during sequential tone-eliciting actions was affected by task type (cooperative vs. parallel), indicating that forming integrated representations of the co-actors and one's own actions induce common evaluative and predictive processes for self-induced and observed actions.

Predicting the fate of basketball throws: a psychophysics and EEG study in healthy and paraplegics athletes.

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Elite athletes can predict successful free shots more rapidly and accurately, with cues of body kinematics, also reflected in their motor activation for successful and unsuccessful shots (Aglioti et al., 2008). Psychophysics studies indicate that paraplegic athletes may fine tune their ability to process pictures of body parts involved in the practiced sport (Pernigo et al, 2012). Here we explored the behavioral and electrocortical underpinnings of wheelchair athletes who predict the fate of throws to basket performed by paraplegic athletes. Using EEG, we searched for the possible electrocortical correlates of observing domain specific actions and predicting their outcome. Expert wheelchair basketball (WCB) players with two levels of physical movement capability were chosen (Points 1 and 4; former with most severe disability, least trunk movement and latter with least severe disability, most trunk movement). Thus far no study has focused on the AON modulation contingent upon expertise and severity injury in people with body-brain somatosensory and motor disconnection.

10 athletes and 19 healthy participants observed free throw videos (“IN” – correct movement execution; "OUT" – incorrect movement execution). They were asked to predict the outcome of the shot which was occluded by a black screen. Preliminary behavioral results highlight a significantly higher performance for the expert players to detect the error in OUT shots, while the healthy subjects only were able to predict shot outcomes at chance level. Furthermore, the players had significantly stronger P300 response compared to naïve healthy subjects over parietal electrodes, both for IN and for OUT videos. Moreover, the P300 response was greater for Point 4 players, which are not only experts, but also have a wider range of motor representations due to less injury, compared to Point 1 players. This suggests that the P300 modulation might be a correlate of motor expertise during action observation.

It's not you, it's me: the impact of visual feedback on motor awareness, agency and body ownership in anosognosia for hemiplegia.

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Differentiating between self and others, and recognising whether an action originated from us, are key to self-consciousness and social interactions. Patients with Anosognosia for Hemiplegia (AHP; i.e. unawareness of hemiplegia) offer unique insight into specific components of self-consciousness. Existing research has found that motor expectations are fundamental to self-awareness (Fotopoulou et al., 2008); however, it remains unclear to what extent the congruency of visual feedback and expectations of movement affects AHP patients' awareness of movement, sense of agency (i.e. the sense of being in control of one's actions) and ownership (i.e. the sense that our body is our own). To this aim, nineteen right-hemisphere stroke patients with AHP and twenty non-anosognosic hemiplegic patients (HP) were asked to perform a movement with their left paralysed arm, and were provided with visual feedback via a rubber hand that was either congruent (i.e. the rubber hand moved) or incongruent (i.e. no movement occurred) with patients' expectations of movement. Self-reports of motor awareness ("Has the hand moved?"), agency ("Was it you that moved it?") and ownership ("To what extent do you feel this is your hand?") were obtained following attempted movements. We found that congruent visual feedback led to higher ratings of agency ($Z=-3.111$, $p<0.01$), with AHP patients reporting higher agency than HP ($Z=-2.585$, $p<0.01$). Moreover, AHP patients were more likely than HP to claim the rubber hand moved when visual feedback was incongruent with their expectations ($Z=-2.711$, $p<0.01$). Finally, AHP patients showed a significant decrease in ownership following incongruent feedback ($Z=-2.089$, $p<0.05$). These findings suggest that when visual feedback is incongruent with expectations of movement, AHP patients experience decreased motor awareness, agency and ownership of the paralysed limb compared with HP. This supports the idea that AHP patients' expectations of movement deeply affect their sense of self, with possible repercussions on self-other distinction.

Social proficiency and its relationship to socially-adaptive mirror system functioning.

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The action observation network or 'mirror system' has been proposed as one of the basic neural mechanisms for socio-cognitive (dys)functioning. However, individual differences in terms of social proficiency are prevalent in the neurotypical population. In this study, we therefore explored whether inter-individual differences in social responsiveness and/or attachment towards others are related to one's ability to show (socially-adaptive) mirror system functioning.

56 neurotypical participants were assessed on adaptive mirror system functioning by means of transcranial magnetic stimulation (TMS). While undergoing TMS, participants observed video stimuli of an actress performing simple hand movements combined with either direct or averted gaze. In general, TMS-assessed mirror responses are significantly larger upon the observation of actions accompanied by direct gaze, compared to averted gaze, which is indicative of a top-down modulation of the mirror system according to the social context. Inter-individual differences in social proficiency were investigated by means of the Social Responsiveness Scale (SRS) and the State Adult Attachment Measurement (SAAM) questionnaires.

The data-driven k-means cluster analysis technique revealed two meaningful profiles of social proficiency. The first cluster represented participants with secure attachment styles and high levels in social proficiency (i.e. 'Secure' cluster). Cluster 2 represented participants that are highly socially avoidant and have mild to severe impairments in social responsiveness (i.e. 'Avoidant' cluster). Although he general level of mirroring was similar for each group, the subgroups showed a clear differentiation in terms of socially-adaptive mirror system functioning. Only for the 'Secure' social profiles, but not for participants belonging to the 'Avoidant' cluster, direct gaze specifically enhanced mirroring.

To conclude; in participants that are less socially proficient, mirroring is intact, but it is not socially modulated by relevant social cues, such as eye gaze. In other words, individuals with social difficulties can mirror, but fail to modulate mirror system functioning according to the social context.

Neurophysiological mechanisms of conversation investigated with fMRI

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Conversation is ubiquitous in interactions. However, little is known about its underlying neural bases, due to technical and methodological challenges, such as devising proper control conditions. This project tackles this challenge by investigating the neurophysiological bases of conversation between two humans compared to that of a human and an artificial agent, using functional magnetic resonance imaging (fMRI). Artificial agents provide valuable control conditions: they appear human-like, yet are perceived as non-human agents. We will implement an established conversation paradigm (Chaminade, 2017) between a participant inside an MRI scanner, engaging in conversation with a human (confederate) or an artificial agent outside. A cover story enables free, albeit topic-oriented, conversation.

We aim to establish the Social Involvement in Conversation (SIC) index, extracting linguistic cues associated with the orchestration of conversation, at the acoustic-prosodic (e.g. *speech rate, pitch range, intensity*), lexical (*specific lexical markers for example associated with attitudes and emotions related feedbac*k), conversational (e.g. *between speakers turn latencies, back-channels rate...*) level.

The project is currently run, results will be presented in May.

We will use whole-brain analysis, the amount of produced and perceived speech as covariate, in SPM block design. We expect conversation between humans (versus human - artificial agent) to activate brain areas involved in social cognition (temporo-parietal junction, medial prefrontal cortex, associated with mentalizing; left hypothalamus, specifically paraventricular hypothalamic nuclei, releasing oxytocin, associated with bondedness). We further aim to use event-related fMRI analysis to correlate the SIC index with neurophysiological parameters during conversation. The SIC index will specifically be correlated with social-reward related areas (hypothalamus, the ventral striatum and orbitofrontal cortex). It will also assess whether activity in speech areas (e.g. Wernicke, Broca) correlates with social involvement in conversation. This project pioneers the investigation of the neurophysiology of bidirectional conversation, the pivot communication tool in interactions.

A matter of (inner) balance: the association between facets of mindfulness, attention deficit, and postural stability.

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Mindfulness and motor performance are theoretically related through attention and awareness, yet little research has been conducted to date. The present study was aimed at exploring the role of facets of mindfulness in static and dynamic balance tasks. Specifically, 103 college students and staff completed the five facets of mindfulness questionnaire (which assesses awareness, non-reacting, non-judging, observing, and describe) and participated in eight motor tasks (e.g., standing on one foot, tandem walk, etc.). Motor performance was assessed by measuring participants' mediolateral trunk sway using Microsoft Kinect 3D sensor. Hierarchical regression analyses revealed that the facet of observing was associated with more stable performance in the absence of visual information. Furthermore, predisposed awareness was associated with less stable performance when attention was divided and in the absence of visual information. Moreover, awareness interacted with attention deficit disorder, such that as compared to non-ADD/ADHDs, participants diagnosed with ADD/ADHD performed worse in static balance tasks if their awareness was low, but performed better if their awareness was high. However, an opposite pattern was found for dual-task gait performance, thus indicating on stereotype threat effect. These findings are discussed from the perspectives of recent mindful movement and the fringe consciousness frameworks.

Is Your Partner's Variability Helpful or Detrimental in Joint Motor Learning?

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Wu et al., 2014, suggests that an individual's natural motor variability can predict the rate at which she learns a motor task. They demonstrated that individuals exhibiting higher motor variability were faster at learning a motor task, presumably because variability fosters exploration of a wider space of motor parameters. Thus, variability seems to enhance motor learning. In joint action, the reduction of variability of an individual's movements is adopted as a coordination strategy for enhancing predictability of one's movement (Vesper et al., 2011). However, it is unclear how individuals regulate variability while learning a motor task together with a partner who exerts variability on to one's movements. The current study aims at investigating how variability is exploited in such scenarios. One prediction would be that a partner producing high variability will be advantageous for learning, as partner's variability might enhance action exploration for the individual. If this was the case, individuals performing the task with a highly variable partner will learn faster than individuals performing the task with a less variable partner. Alternatively, a higher variability from the partner could be detrimental because high variability might prevent individuals to reliably predict the partner and optimize the individual learning along with the joint goal. In a joint sequence learning paradigm, participants learned a motor task jointly with a confederate who was either highly variable or less variable in his movements. A haptic coupling between the actors allowed translation of partner's movement variability into a force perturbation. In two experiments, we tested how different degrees of predictability of force perturbations coming from the partner could foster or hamper individual motor learning. Our preliminary results indicate that participants perform worse when partner produces entirely unpredictable forces. This suggests that impeding the predictability of the partner, might negatively influence the learning performance.

Intention is in the action: reach-to-grasp kinematics primes the intent towards an object

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Can movement kinematics prime intention identification? Previous research has shown the interactions between observed visual stimuli and the kinematics of a subsequent executed act i.e. the visuomotor priming effect. The aim of the present study is to investigate whether the kinematic information can prime the reaction time of intention identification, using a visuomotor priming paradigm. Twenty participants were instructed to respond as quickly as possible to target stimulus, represented by images in which an actor was intent to drink water from the bottle or to pour some water inside a glass, identifying the corresponding intention. Prior to the target stimulus, movement prime videos were presented. The movement prime that depicted a reach-to-grasp performed either with an intent to drink or to pour, could be congruent or incongruent with the target stimulus. The results show that the movement kinematics were successful in priming participants' response times. Response times were longer after an incongruent prime compared to congruent movement kinematics primes. These findings suggest that the intention specific information present in movement kinematics is processed in an automated manner even without any explicit instruction and this information influences the reaction times. These data could be interpreted as evidence of a link between automatic processing of observed movement and the direct expected consequence in terms of action chain.

Improvement of audio-tactile multisensory interaction in a peripersonal task after auditory training.

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Peripersonal space (PPS) is created by a multisensory interaction between different sensory modalities and can be modified by experience. In this article, we investigated whether a training aimed at boosting the spatial perception of auditory information, based on echolocation, can modify the PPS around the head in sighted participants. We measured the participant's reaction times to a tactile stimulation, while task-irrelevant looming auditory stimuli were presented. Sounds more strongly affect tactile processing when located within a limited distance from the body, so we measured spatially-dependent audio-tactile interaction as a proxy of PPS representation before and after an echolocation training. We found a significant speeding effect on tactile RTs after echolocation, specifically when sounds where around the location where the echolocation task was performed. This effect could not be attributed to a task repetition effect nor to a shift of spatial attention, as no change of PPS was found in two control groups of participants who performed the PPS task after either a break or a temporal auditory task (with stimuli located at the same position of echolocation task). These findings show that echolocation affects multisensory processing inside PPS representation, likely to better represent the space where external stimuli have to be localized.

The role of the dorsolateral prefrontal cortex in the expectation-induced enhancement of force: a tDCS study

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Expectation, induced through a placebo procedure, can improve motor performance. Knowledge on the brain regions involved in this motor placebo effect is still scant. In this study we aim at investigating the role of the dorsolateral prefrontal cortex (dlPFC), which is involved in cognitive functions, like anticipation and expectation, in the motor placebo effect. To this purpose, transcranial direct current stimulation (tDCS) was applied over the left dlPFC during a placebo procedure.
We ran three different experiments: two with placebo procedures and one with a control procedure. In each experiment, all the participants received anodal, cathodal and sham stimulation over the dlPFC in counterbalanced order and had to perform a motor task by pressing as strongly as possible a piston with the right index finger. In the first placebo experiment, we applied transcutaneous electrical nerve stimulation (TENS) as inert treatment to the muscle involved in the task by telling the participants that TENS increased force. These subjects were also conditioned about the effects of TENS with a surreptitious increase of the visual feedback of force. In the second placebo experiment, participants performed the same motor task, but only with verbal suggestion about TENS. In the control experiment, participants performed the motor task, but they were clearly informed that TENS does not have effects on force.
We found stronger force levels at the end of the procedure in the two placebo experiments and not in the control experiment. This confirms that the paradigm was suitable to induce a motor placebo effect. Moreover, in the second placebo experiment, the placebo effect was reduced by anodal and cathodal tDCS compared to sham selectively in placebo responders.
It appears that independently of the polarity, tDCS over the left dlPFC disturbs the motor placebo effect in those subjects who receive only verbal suggestion.

Multimodal exergames: case studies in pediatric rehabilitation

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This poster illustrates the use of a platform for multimodal full-body rehabilitation. The platform is aimed at complementing standard rehabilitation at ARIEL (Augmented Rehabilitation in Interactive/multimodal Environment Lab), a joint laboratory between pediatric hospital Istituto Giannina Gaslini (Genoa, Italy) and the University of Genoa. Technology is nowadays increasingly used in quite every aspect of our life. Although research on the positive effects of multisensory stimulation for rehabilitation processes is available, current technologies often do not still sufficiently ground on recent neuroscientific and cognitive results, not exploiting enough the potential of multisensory and multimodal interactive design. Furthermore, multimodal technologies afford the opportunity to capture non-verbal multimodal children's behavior, to foster children's agency by leveraging different communication modalities, to introduce more motivating elements in the rehabilitation session and to keep track of past sessions history. The work we present is focused on the use of full-body multimodal adaptive rehabilitation games, suited to stimulate multisensory processing and integration in impaired children. The poster demonstrates the design of a flexible and modular open platform for nonverbal interactive child rehabilitation exergames, with a specific focus on interactive sonification of motor behavior. Three exergames, namely CULT (Cognitive Upper Limb Trainer), HTCT (Head Trunk Conrol Trainer) and CERT (Coordination Endurance Rehab Trainer), each addressing the rehabilitation of different cognitive and motor skills, are presented. Moreover, 6 case studies illustrate the use of the exergames for the rehabilitation of pediatric patients, each varying in terms of diagnosis: bilateral cerebral palsy, visual and behavioral impairments, speech dyspraxia, motor impairments (e.g. coordination and gait difficulties) and attentional deficits. Our results show that a multimodal platform for full-body rehabilitation training can enhance the functionality of impaired children, foster their motivation, and help them become more confident while interacting in a protect and engaging environment.

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