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INTERNATIONAL MULTISENSORY RESEARCH FORUM

IMRF

24-27th June 2026

Genoa

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ISTITUTO ITALIANO DI TECNOLOGIA
UNIT FOR VISUALLY IMPAIRED PEOPLE

COMUNE DI GENOVA

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SCHEDULE OF EVENTS

JUNE 24th

8:30 am- 1:00 pm	Pre-conference scientific workshops
8.30 am- 10.45 am ALISEO Room	Scientific workshop 1 From measurement to modelling: Essential methods for multisensory reaction time research. *Otto Thomas, Roberts Kalvin*
ZEFIRO Room	Scientific workshop 2 Sound and gaze in three dimensions – speaker based spatialized audio and eye movements in the real world. *Watson Marcus R., Villar Ortega Eduardo*
10.45 am- 1.00 pm ALISEO Room	Scientific workshop 3 The Multisensory Correlation Detector: a hands-on workshop for modelling audiovisual perception. *Parise Cesare*
ZEFIRO Room	Scientific workshop 4 Introduction to Python and AI-based image analysis. *Vannucci Fabio, Senacheribbe Andrea*
12:00 pm- 1:30 pm	Welcome desk Registration
1:30 pm- 1:45 pm SCIROCCO Room	Opening Remarks
1:45 pm- 3:00 pm SCIROCCO Room	Symposium 1 Fifty years of "Hearing lips and seeing voices": the golden anniversary of the McGurk Effect. *Noppeney Uta, Tiippana Kaisa, Lalor Edmund, Beauchamp Michael*
3:00 pm- 4:15 pm SCIROCCO Room	Young Researcher Talk Session sponsored by European Journal of Neuroscience Neural correlates of audiovisual gaze-orienting in common marmosets. *Cook Tyler* Exploring the role of auditory efferences in Eye Movement-Related Eardrum Oscillations. *Sotero Silva Nancy* Reassessing the Sound-Induced Flash Illusion: a reanalysis of 72 studies and over 150,000 trials. *Mittal Jahanvi* Effect of autism spectrum disorder on multisensory integration and sensory sensitivity. *Luszawski Michelle*

	Evaluation of individual modality-specific cognitive profile: dissociation between objective and subjective measures. *Bertolucci Lisa*
4:15 pm- 4:45 pm	Coffee Break
Hall	
4:45 pm- 6:00 pm	Symposium 2
SCIROCCO Room	Multisensory and sensorimotor integration mechanisms defining the self. *Noel Jean-Paul, Sebastiano Alice Rossi, Bertoni Tommaso, Serino Andrea*
6:00 pm- 7:00 pm	**Keynote 1: Professor Casey O'Callaghan**
SCIROCCO Room	What's to fear in losing a sense?
7:00 pm- 10:00 pm	Welcome Aperitivo
Hall	

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SCIROCCO Room	Spontaneous eye movements reveal tactile localization on canonical body representations. *Gerin Sylvain*
	Tactile localization along the arm. *Khoury Jason*
	Investigating the vestibular contributions to body perception when reaching to somatosensory targets. *Pitino Jonathan*
	The multisensory correlation detector model explains temporal integration in the rubber hand illusion. *Litwin Piotr*
	Individual differences in bodily illusions suggest individual differences in causal inference. *Fairchild Grant*
PONENTE Room	Talk Session 2. Multisensory development
	When width and height disagree: development of cross-modal spatial perception. *Coelho Lara*
	A comprehensive neurocomputational framework to study the emergence of multisensory perception in the developing brain. *Di Rosa Eleonore Federica*
	Neural synchronization with audiovisual speech depends on a sensitive period. *Fantoni Marta*
	EEG measures of multisensory reading comprehension in autistic children. *Hinchey Sarah*

	Beyond perceptual reports: an EEG-based paradigm to estimate multisensory temporal binding windows in pre-verbal populations. *Venturini Camilla*
	Disrupted top-down modulation as a mechanism of impaired multisensory processing in autistic children. *Vanneau Theo*
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Hall	
11:45 am- 1:15 pm	Symposium 3
SCIROCCO Room	Touch, body, and space: rethinking tactile localization. *Fossataro Carlotta, Hoffmann Matej, Fuchs Xaver, Peviani Valeria, Badde Stephanie*
PONENTE Room	Symposium 4
	The sensory-motor brain organization and its role in cognition/life. *Aggius-Vella Elena, Vaccari Francesco, Monaco Simona, Serino Andrea, Amedi Amir*
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Hall	
2:15 pm- 3:45 pm	Symposium 5
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PONENTE Room	Symposium 6
	Multisensory integration and aging: cognitive, motor, and brain health implications. *Newell Fiona N., Campos Jennifer L., Martinelli Isabella, Marusic Uros, Amedi Amir*
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	Visual context and auditory ambiance shape sound localization and head- movement behavior in immersive VR. *Hassani Pouriya*
	The impact of tactile stimulation in sound source localization. *Lever Lisa*

The cross-modal nature of touch representation in the human brain: Inter subject correlation revealed shared. *Castellani Nicolò*

The neural organization of visual information in the auditory cortex of the congenitally deaf. *Tal Zohar*

Underlying neural mechanisms of multimodal information processing: the case of Visual Word Form Area's responses to speech. *Pattamadilok Chotiga*

PONENTE Room — Talk Session 4. Computational approaches to multisensory processing

Begging the body: Bayesian causal inference does not explain body ownership. *Lenti Matteo Mauro*

Causal inference in the robotic hand illusion. *Rohe Tim*

Offloading or interfering? Social effects on causal inference in multisensory integration. *Wahn Basil*

Scikit-NeuroMSI: a generalized framework for modelling multisensory integration. *Paredes Renato*

Phoneme overlap analysis of the visual benefit for speech-in-noise perception. *Magnotti John*

Development of multisensory decision-making: from unisensory dominance to reliability-weighted integration. *Diaz Jessica Ann*

6:30 pm- 7:45 pm SCIROCCO Room — Optional Networking Workshop 1

Improv-based tips for researchers. *Zanchi Silvia*

PONENTE Room — Optional Networking Workshop 2

Painting sensory modalities. *Gori Monica*

JUNE 26th

9:00 am- 10:30 am — Talk Session 5. Active sensing and sensorimotor integration

SCIROCCO Room

Multisensory number channels derived from individual differences. *Burr David*

Incidental learning from unimodal and multimodal associations. *Roark Casey*

Tactile modulation during movement. *Fiehler Katja*

The effect of otolith noise on vestibular perceptual latency and temporal binding windows. *Perry Emily*

Modality-dependent delay adaptation in sensorimotor temporal reproduction. *Chen Lingyue*

	Do eye movements shape how we hear? Oculomotor control of auditory cortex and perception during active sensing. *Leszczynski Marcin*
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	Cross-modal temporal recalibration does not accumulate across sessions. *Bruns Patrick*
	Modality-specific serial dependence effects for judgments on auditory and visual motion direction. *Stoyanova Kalina*
	The Shepard Swing: tracking endogenous bistability beyond vision. *Domenici Nicola*
	Multisensory timing meets evidence accumulation in MS. *Bollini Alice*
	Testing candidate processes to explain individual differences in audiovisual integration using a novel cue. *Chazelle Thomas*
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11:45 am- 1:15 pm	Symposium 7
SCIROCCO Room	Proprioceptive contribution to multisensory body representations and neuroplasticity in normal and pathological contexts. *Bruno Valentina, Bassolino Michela, Radziun Dominika, Bove Marco, Papaxantis Charalambos*
PONENTE Room	Symposium 8
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	Illusions as tools to probe the multisensory mind: implications for sensory theory, neuroplasticity, and individual differences. *Stiles Noelle, Shimojo Shin, Jiang Fang, Sherman Aleksandra, Herzog Michael H.*
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5:00 pm- 6:00 pm	Keynote 2: Professor Maria Concetta Morrone
SCIROCCO Room	Plasticity of early visual processes is gated by top-down signals

JUNE 27th

9:15 am- 10:30 am	Symposium 11
SCIROCCO Room	Multisensory stimulation and visual rehabilitation. *Bolognini Nadia, Reber Michael, Rowland Benjami, Cuppini Cristiano*
10:30 am- **11:45 am**	Poster Session 5 & Coffee Break
Hall	
11:45 am- 12:45 pm	Keynote 3: Professor Johan Wagemans
SCIROCCO Room	Multiple roads to aesthetic appreciation of art
12:45 pm- 1:00 pm	Award Ceremony
SCIROCCO Room	
1:00 pm- 1:30 pm	Closing Remarks & Business Meeting
SCIROCCO Room	

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CONFERENCE VENUE

The conference will take place at the conference center Magazzini del Cotone (address: Magazzini del Cotone, Via Magazzini del Cotone, 59, 16128 Genoa GE).

Located in the heart of the Porto Antico, the Magazzini del Cotone is a waterfront complex originally built between 1889 and 1926 as warehouses for storing cotton. After extensive renovations led by architect Renzo Piano in 1992 for the Columbian Expo, the site was transformed into a vibrant cultural and conference center.

How to reach Magazzini del Cotone

From Genoa Cristoforo Colombo Airport

- Volabus: Take the Volabus shuttle from the airport to Piazza De Ferrari (approx. 30 minutes, €6). From there, walk (~10 min) or take the metro to San Giorgio station, which is 600 meters from Magazzini del Cotone
- Airlink + Train: Take the Airlink shuttle to Sestri Ponente station, then a regional train to Genova Piazza Principe. From there, follow the directions below
- Taxi: At the Arrival Terminal, exit and there are taxis in the waiting lane. Approximate cost to the conference venue: €25

From Genoa City Center (Piazza De Ferrari)

- Metro: Board the metro at the De Ferrari station and get off at San Giorgio. Walk 600 meters to Magazzini del Cotone
- Walking: Approximately 16 minute walk

From Genoa Brignole Station

- Metro: Take the metro towards Brin and get off at San Giorgio
- Bus: Use the bus line 13 and get off at Piazza Caricamento
- Walking: Approximately 34 minute walk

From Genoa Piazza Principe Station

- Metro: Board the metro towards Brignole and get off at San Giorgio
- Bus: Take bus line 1 or 35 and get off at Piazza Caricamento or Gramsci 2
- Walking: Approximately 34 minute walk

Conference Rooms Organization

Entrance

- Module 8 - the entrance is at the ground floor, from the walking area, not from the seaside

3rd floor

- Sala Scirocco → plenary sessions, parallel sessions
- Hall → poster session
- Registration desk

2nd floor

- Sala Ponente → parallel sessions
- Sala Aliseo → workshops
- Sala Zefiro → workshops

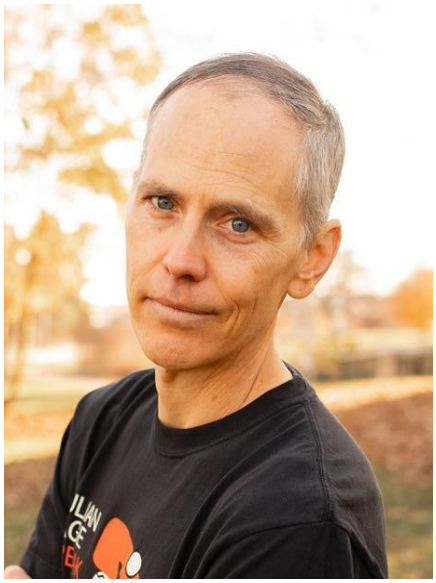
Parkings

- P1–P2 → Calata Molo Vecchio, 16128 Genova (2-3 mins walking distance from Module 8)
- P3–P4 → Calata Gadda, 16126 Genova (5-7 minutes walking distance from Module8)

KEYNOTE SPEAKERS

Professor Casey O'Callaghan

Washington University



Casey O'Callaghan is Professor of Philosophy and Director of the Philosophy-Neuroscience-Psychology Program at Washington University in Saint Louis. O'Callaghan's research aims at an empirically informed understanding of sensory perception that is driven by thinking about non-visual modalities and the relationships among the senses. His publications have focused upon auditory perception, speech perception, cross-modal illusions, multimodality, synesthesia, perceptual plasticity, and sensory disabilities and diversity. O'Callaghan is author of Sounds: A Philosophical Theory; Beyond Vision: Philosophical Essays; and A Multisensory Philosophy of Perception. He received a B.A. in Philosophy and Cognitive Science from Rutgers University and a Ph.D. in Philosophy from Princeton University. Website: http://caseyocallaghan.com/

KEYNOTE 1

JUNE 24th | 6:00 pm- 7:00 pm

SCIROCCO ROOM

What's to fear in losing a sense?

Many people fear losing one or more of their senses, and most fear losing some more than others. However, if a disability such as being without the use of a sense does not in the long run make a person worse off, then such fears may not seem reasonable, warranted, or apt. This talk argues that our senses are distinctive sources of value. In particular, our senses play an underappreciated axiological role. They figure deeply in our cares, concerns, and projects, and they are sources of final or non-instrumental value. Moreover, different senses comprise distinct collections of perceptual capacities that contribute in distinctive ways to a person's cares, concerns, and projects. Therefore, from one's present evaluative perspective, it makes sense to fear the loss of such a distinctive source of value, and it makes sense to fear the loss of some senses more than others, even if, after adapting, the loss of a sense does not impact one's overall, long-term well-being.

Professor Maria Concetta Morrone

University of Pisa

Maria Concetta Morrone is Professor of Physiology in the School of Medicine of the University of Pisa, and Member of the Italian National Academy Lincei (Academia Nazionale dei Lincei) and of the Academia Europaea. She is the President of the Italian Society for Neuroscience. From an initial interest in biophysics and neurophysiology, where she made many seminal contributions, her scientific interest moved on to psychophysics, visual perception, and functional imaging in human and clinical populations. Over the years her research has spanned spatial vision, development, plasticity, attention, color, motion, robotics, vision during eye movements, multisensory perception, time perception and action. She is currently developing appropriate techniques for ultra-high field (7T) for studying BOLD with the resolution of cortical layer.

KEYNOTE 2

JUNE 26th | 5:00 pm- 6:00 pm

SCIROCCO ROOM

Plasticity of early visual processes is gated by top-down signals

Plasticity of neuronal circuitry is a core function of the brain. One of the most striking examples in humans is that massive central lesions in neonates, such as complete unilateral lesions of the occipital pole or thalamus, may result in only minor visual deficits, due to massive brain reorganization. Reorganizations are not limited to vision, but also involve other sensory and motor systems that re-align with the altered visual function. Plastic changes in the visual cortex are not restricted to the developmental period, but can extend throughout adult life. For example, transient deprivation of vision in one eye in adults leads to a reorganization of visual circuitry, enhancing the representation of the deprived eye. These effects are observed in both the primary and associative visual cortexes, as well as in the pulvinar (but not in the lateral geniculate nucleus), suggesting that cortical feedback may play a crucial role in modulating plasticity. Deprivation in adults correlates with a decrease in pulvinar–cortical functional connectivity, with minimal changes in cortical–pulvinar connectivity in the opposite direction. These results challenge the classical view that visual plasticity is driven solely by intra-cortical processing. To further address this issue, we recently manipulated the temporal delay of visual input between the two eyes, generating conflicting monocular images. Incongruent visual information to the two eyes can induce plastic changes, but only when combined with action on the incoming sensory input. This finding reinforces the view that visual plasticity is not purely a visual process, but is influenced by top-down cognitive signals—likely mediated through the pulvinar—related to intention, prediction, attention, motivation, and possibly theory of mind. What could be the functional role of this type of transient plasticity in adults? We have shown that short-term effects can stabilize into long-term changes, beneficial for the treatment of amblyopia in adults, by combining visual deprivation with physical exercise, again implicating top-down feedback mechanisms, and suggesting a practical application for the induced plasticity.

Professor Johan Wagemans

University of Leuven

Johan Wagemans is Full Professor at the Department of Brain & Cognition at the University of Leuven (KU Leuven) in Belgium. He has published more than 350 papers in international peer-reviewed journals, has edited the Oxford Handbook of Perceptual Organization, and is Editor-in-chief of Cognition and Art & Perception. He is currently leading two large interdisciplinary research programs on perception and appreciation of images and art, one funded by the Flemish Government (Methusalem) and one funded by the European Research Council (GRAPPA). In this context, together with his PhD students and postdocs, he is conducting experimental and computational research on the aesthetics of images (natural images, professional photography, and paintings), using online studies, image statistics and machine learning, as well as multi-methods studies on aesthetic experiences in museum contexts. Some of these are also focused on multisensory aesthetic experiences (e.g., audio-visual Ganzfeld, visuo-tactile sculptures).

KEYNOTE 3

JUNE 27th | 11:45 am- 12:45 pm

SCIROCCO ROOM

Multiple roads to aesthetic appreciation of art

Art can be appreciated for various reasons: prize, fame, its formal qualities, meaning, the memories and emotions it evokes, the context of the museum, and so forth. Focusing on the aesthetic aspects, multiple factors have been identified as possible determinants, ranging from perceptual aspects such as color, size, and perceived materiality to higher-level factors such as style, content, the message, and the cultural importance. Aesthetic aspects also entail various dimensions, including beauty, liking, preference, and various special ones such as awe and the experience of the sublime. Moreover, various theories and models have been formulated about how humans come to such aesthetic appraisals, emphasizing mere exposure, optimal arousal levels, perceptual and conceptual fluency, etc. In recent years, we have seen more synthetic approaches such as the pleasure-interest model and the predictive processing account, both emphasizing that there are multiple roads to aesthetic appreciation. After a brief sketch of this broad background, I will focus on the perceptual aspects of aesthetic appreciation, at all levels (low, mid, high). In particular, I will present and discuss some of the recent work in our lab on Ganzfeld art, in which the brain creates its own experience with limited homogeneous external stimulation (colored light fields, auditory noise), and on the visual and tactile exploration of sculptures. I will conclude with two suggestions for the empirical aesthetics of art: to be open-minded about the multiple roads to aesthetic appreciation of art (determinants, mechanisms, dimensions, outcomes, and even research methods), and to conduct more research on the different sensory modalities involved in our interactions with and experiences of art.

PRE-CONFERENCE SCIENTIFIC WORKSHOPS

SCIENTIFIC WORKSHOP 1

JUNE 24th | 8:30 am – 10:45 am

ALISEO ROOM

From measurement to modelling: Essential methods for multisensory reaction time research

Otto Thomas (1)

1 - School of Psychology & Neuroscience, University of St Andrews (United Kingdom)

Multisensory research relies hugely on reaction time (RT) measures to quantify behavioral benefits and identify underlying processing mechanisms. This workshop provides an accessible yet rigorous overview of best practices for collecting, analyzing, and modelling RT data in multisensory experiments. We begin by outlining key considerations in RT measurement, including hardware and software timing precision, response devices, trial structure, and strategies to maximize multisensory benefits. The workshop then introduces fundamental analytical procedures, emphasizing the probabilistic nature of RTs and the importance of distribution-level approaches beyond mean-based summaries. Attendees will learn practical methods for visualizing and characterizing RT distributions and summarizing RT distributions across participants. Building on this foundation, the workshop covers core modelling techniques used to test multisensory processing accounts. We illustrate the classic race model and its inequality test, discussing implementation, interpretation, and common pitfalls. Finally, to support robust inference about multisensory integration mechanisms, we provide guidance on fitting parametric RT distributions and offer a concise introduction to model development. Designed for researchers at all levels, this workshop aims to strengthen methodological literacy and promote reproducible, theory-driven analysis of multisensory reaction time data.

SCIENTIFIC WORKSHOP 2

sponsored by Multisensory Environments to study Longitudinal Development

JUNE 24th | 8:30 am – 10:45 am

ZEFIRO ROOM

Sound and gaze in three dimensions - speaker based spatialized audio and eye movements in the real world

Watson Marcus R. (1), Villar Ortega Eduardo (2,3)

1 - Vanderbilt University, Nashville (United States)
2 - Radiology Department, Lausanne University Hospital and University of Lausanne, Lausanne (Switzerland)

3 -The Sense Innovation and Research Center, Lausanne and Sion (Switzerland)

Many experimenters need to present stimuli that resemble real-world objects and environments, and to record the resulting behaviours in all their glorious complexity. However, this freedom leads to very steep learning curves. This workshop will introduce attendees to open-source methods for dealing with these challenges. On the stimulus side, we will cover 3D spatial audio, and on the behavior side, we will cover gaze to arbitrary objects. We will review speaker-array-based methods of audio spatialization (VBAP and ambisonics). After a brief introduction to the theory behind these methods, we will learn how to (a) select optimal speaker locations for a given room, (b) use speakers at these locations to present sounds from any location in the room, (c) objectively verify the fidelity of these presentations using multi-directional microphones, and (d) synchronize them with other lab equipment using Lab Streaming Layer (LSL). We will next review how to collect, process and analyze mobile eye-tracking data in real-world multisensory experiments, covering (a) preprocessing pipelines, including LSL-based synchronization, blink handling, and filtering of gaze signals; (b) gaze-to-stimulus mapping by projecting mobile eye-tracker coordinates onto experimental displays, with considerations for dynamic environments and participant movement; (c) area-of-interest (AOI) analysis using multiple definition strategies (circular, Voronoi, constrained Voronoi, and grid-based), with quantitative validation through spatial precision metrics such as dispersion ellipses; and (d) race-model analysis applied to both button-press reaction times and oculomotor latencies. Attendees will leave with skills and tools that should reduce the time from conceptualizing a dynamic, three-dimensional experiment to actually implementing one.

SCIENTIFIC WORKSHOP 3

JUNE 24th | 10:45 am – 1:00 pm

ALISEO ROOM

The Multisensory Correlation Detector: a hands-on workshop for modelling audiovisual perception

Parise Cesare (1)

1 - University of Liverpool (United Kingdom)

The Multisensory Correlation Detector (MCD) provides a biologically grounded framework for understanding how the brain combines information across the senses. A key strength of the model is that it is stimulus-computable: instead of relying on experimenter-defined stimulus parameters, it operates directly on raw audiovisual input and reproduce a wide range of phenomena in multisensory perception. Because of this feature, working with the MCD involves a mode of analysis that differs substantially from more conventional approaches in the field. For researchers who are unfamiliar with computational modelling or mathematically oriented methods, this shift can seem challenging at first. This workshop is designed as an accessible introduction to the model and its logic. Attendees will be guided through practical examples showing how the MCD can be applied to model classic findings in the spatial and temporal domains of audiovisual perception. The session will combine conceptual explanation with hands-on exercises, giving attendees the opportunity to learn how to implement the model in practice. No prior programming experience is required. Attendees should bring a laptop with MATLAB installed, including the Statistics and Machine Learning Toolbox. They are also encouraged to bring their own stimuli or datasets if they would like to discuss how the MCD might be applied to their own research.

SCIENTIFIC WORKSHOP 4

sponsored by MuItisensory Environments to study Longitudinal Development

JUNE 24th | 10:45 am – 1:00 pm

ZEFIRO ROOM

Introduction to Python and AI-based image analysis

Vannucci Fabio (1), Senacheribbe Andrea (1)

1 – Italian Institute of Technology (Italy)

This workshop offers a practical introduction to Python programming as a foundation for working with visual data. The first part introduces the basic concepts of the Python language, providing attendees with the essential tools needed to understand and write simple scripts. The second part of the workshop focuses on the use of open-source artificial intelligence libraries for image analysis. Through guided examples, attendees will learn how to automatically extract visual features from images or video frames, such as detecting faces, identifying facial expressions, or recognizing the presence and position of hands and simple gestures (e.g., pointing or giving a thumbs-up). Finally, the workshop will demonstrate how the extracted data can be used for basic exploratory data analysis. Attendees will see simple examples of how to compute and interpret basic statistics from the extracted features, providing a brief practical introduction to the next steps in data analysis workflows and more advanced applications.

OPENING

JUNE 24th | 1:30 pm – 1:45 pm

SCIROCCO ROOM

Welcome and Opening Remarks

Monica Gori, Principal Investigator of the Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia

Maria Bianca Amadeo, External Collaborator of the Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia

Giorgio Metta, Scientific Director, Istituto Italiano di Tecnologia

Rita Bruzzone, Councillor for Educational Services, Education Rights, Training, Human Resources, Equal Opportunities and Gender Equality, City of Genoa

SYMPOSIUM LIST

SYMPOSIUM 1

JUNE 24th | 1:45 pm – 3:00 pm

SCIROCCO ROOM

Fifty years of "Hearing lips and seeing voices": the golden anniversary of the McGurk effect

*Noppeney Uta, Tiippana Kaisa, Lalor Edmund, Beauchamp Michael**

**organizer*

In 1976, John MacDonald and Harry McGurk published a Nature paper entitled "Hearing Lips and Seeing Voices." In the decades since, the paper has been cited nearly 10,000 times and has profoundly influenced our understanding of speech perception by providing a simple demonstration that humans integrate information from the voice and face of the talker in the service of understanding. This symposium marks the 50th anniversary of the publication of the illusion by surveying our current understanding of audiovisual speech perception, including the McGurk effect. The symposium will include leading researchers on audiovisual speech perception, and a brief video message from John MacDonald, the surviving co-discoverer of the illusion. Uta Noppeney will present research on Bayesian causal inference models of the McGurk effect and the relationship between the illusion and observers' confidence about their percepts. Kaisa Tiippana, together with her student Ilmari Moisio, will describe the relationship between the acoustic and visual properties of the syllables comprising a McGurk stimulus and the resulting percept. Professor Edmund Lalor will describe brain recording studies (EEG) that show that audiovisual integration during speech perception occurs at different hierarchical levels of representation in the language system. Professor Michael Beauchamp will surbey the past, present and future of the McGurk effect, with an emphasis on recent discoveries, remaining mysteries, and ongoing debates.

Talk: Perceptual and causal confidence in the audiovisual McGurk illusion

Noppeney Uta (1), Beurskens Jochem (1), Meijer David (1), Wlaszczyk Agata (1)

1 - Donders Institute for Brain, Cognition and Behaviour Radboud University, Nijmegen (The Netherlands)

Perceptual decisions come with a sense of confidence. The Bayesian confidence hypothesis posits that confidence corresponds to the posterior probability of being correct. Despite extensive research, it remains unclear how observers compute confidence in complex real-world scenarios with multiple sensory signals, requiring the selection of relevant features and the attribution to their underlying causes. In this study observers were presented with auditory (spoken) syllables, the corresponding visual speech (articulatory lip movements) or congruent and McGurk audiovisual combinations ([ba],[ga]). In a dual-task paradigm, observers identified the first letter of the syllable they heard. They also judged whether the video and audio originated from one source (i.e. causal decision) and reported their confidence for both judgments. Our results show that participants had limited metacognitive

access to conflicting unisensory components, experiencing the McGurk illusion and congruent stimuli as causal and perceptual metamers. Perceptual and causal confidence were closely related, consistent with predictions of Bayesian causal inference models. Moreover, while some observers computed Bayesian confidence optimally, others employed suboptimal strategies, either comparing only the two most likely decision options or applying simple heuristics directly to the sensory space. Our findings highlight deviations from normative Bayesian Causal inference and substantial inter-individual differences in confidence computations in rich naturalistic multisensory environments.

Talk: Acoustic and visual stimulus cues contributing to the McGurk effect

Tiippana Kaisa (1), Moisio Ilmari (1)

1 - Department of Psychology, University of Helsinki (Finland)

The McGurk effect demonstrates that visual speech influences how consonants are heard. In the classic example, an acoustic A[ba/pa] is presented with visual V[ga/ka]. This can be heard according to its components or as their "fusion" [da/ta]. However, it remains unclear how physical stimulus properties influence what is heard. We addressed this by investigating whether the response distributions of 52 participants were predicted by A and V physical cues of [pa], [ta], and [ka]. Six acoustic cues were analyzed: center of gravity and duration of noise burst, and frequency range and duration of second and third formant transitions. It could be hypothesized that the closer A[pa] stimulus is physically to A[ta], the more the McGurk stimulus A[pa]V[ka] would be heard as 'ta'. Linear mixed modeling showed that the second formant transition duration was the strongest cue. In some cases, the hypothesis was supported, e.g., the McGurk stimulus was heard more as 'ta' when the transition of A[pa] resembled that of A[ta], but there were also discrepant findings. Preliminary analyses of seven visual cues (maximum mouth opening, its timing, mouth opening at consonant closure, upper teeth visibility, lower teeth visibility, tongue visibility and image blur) suggested tongue visibility as the strongest cue. The better the visibility, the more the McGurk stimulus A[pa]V[ka] was heard as 'ka', probably because visibility allowed better discrimination of the place of articulation. In conclusion, physical stimulus cues contributed to the McGurk effect. These cues and their joint influences should be studied more systematically in the future.

Talk: A multistage model of natural audiovisual speech integration heavily inspired by the McGurk effect

Lalor Edmund (1)

1 - Departments of Biomedical Engineering and Neuroscience, University of Rochester, Rochester, NY (United States)

It is well known that seeing a speaker's face can greatly improve one's ability to understand what they are saying, especially under adverse hearing conditions. Decades of research suggests that such integrative mechanisms come in two forms based on "when" the audio and visual speech are integrated: 1) early integration at the acoustic level, before speech acoustics have been transformed into linguistic representations; and 2) late integration at the linguistic level, where the visual system supplies its own linguistic representations that constrain the inferences being made about audio speech. This notion that linguistic representations in the visual system can influence late stages of auditory speech processing owes a tremendous amount to the McGurk effect. In this talk, I will describe how we have been inspired by the McGurk effect to consider multistage models of audiovisual integration in the context of natural, continuous speech. I will describe a series of EEG

experiments that provide neurophysiological support for: AV speech integration in the context of natural speech; the idea that that integration occurs at different hierarchical levels of representation; and the idea that that integration is built on linguistic representations within the visual system. I will also briefly discuss some future directions that we are exploring with regard to this multistage model of audiovisual speech integration.

Talk: Fifty years of the McGurk effect: past, present and future

Beauchamp Michael (1), Magnotti John F. (1)

1 - Department of Neurosurgery, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA (United States)

The McGurk effect is a simple illusion that has had remarkable staying power in the literature: the original paper is still cited hundreds of times per year, 50 years after publication. This talk will highlight the richness inherent in the illusion by reviewing the past, present and future of the McGurk effect, with a focus on recent discoveries, remaining mysteries, and ongoing debates. A recent discovery is that the illusion can induce plasticity in auditory speech perception, so called fusion-induced recalibration (FIR). For some observers, repeatedly viewing the same McGurk stimulus changes perception of the auditory component of the stimulus so that it is heard as the fusion percept, even without the accompanying incongruent visual syllable. This shift in perception can be stable for months or years without any additional McGurk exposure. An important remaining mystery is the source of individual variability in the McGurk effect: across many presentations of many different McGurk stimuli, some observers never perceive the illusion, despite normal hearing and vision, while others always perceive it. An ongoing debate concerns the relationship between audiovisual integration during the McGurk effect and during perception of noisy speech. Brain recording (fMRI and iEEG) and stimulation (TMS) studies of both forms of integration will be presented suggesting that the human superior temporal sulcus (STS) is a key neural locus for both kinds of integration.

SYMPOSIUM 2

JUNE 24th | 4:45 pm – 6:00 pm

SCIROCCO ROOM

Multisensory and sensorimotor integration mechanisms defining the self

Noel Jean-Paul, Rossi Sebastiano Alice, Bertoni Tommaso, Serino Andrea*

**organizer*

Perception and action are organized around a body-centered viewpoint defined by the space immediately surrounding the body, known as peripersonal space (PPS), which guides intentional behavior. This symposium will characterize the neural mechanisms of multisensory and sensorimotor integration that give rise to PPS representations and support a minimal form of selfhood, distinguished from the external environment. We will present evidence spanning single-unit neurophysiology, development, computational modeling, and evolution. Jean-Paul Noel will present novel data demonstrating a distance-dependent form of visuotactile integration defining PPS in rodents. While seminal neurophysiological work described PPS neurons in primates, these data address previously unexplored aspects such as connectivity profiles, population dynamics, and modulation during altered states of consciousness. Alice Rossi Sebastiano will show how similar multisensory integration mechanisms emerge at birth and develop through body–environment interactions, presenting electrophysiological data from newborns, infants, and adults. These processes support the emergence of a sense of self distinct from the environment. Tommaso Bertoni will characterize sensorimotor integration mechanisms underlying the sense of self related to one's own body and actions using a novel computational framework supported by psychophysical and electrophysiological results. Finally, Andrea Serino will present work showing that multisensory mechanisms mediating interactions between the individual and the external environment also interact with the immune system, supporting self–other distinction within the body. Together, these findings and theoretical perspectives highlight core multisensory and sensorimotor mechanisms that support a fundamental form of self-definition preserved across species, across the lifespan, and across bodily systems.

Talk: Neural coding of peripersonal space from sensory integration to ego dissolution

Noel Jean-Paul (1)

1 - University of Minnesota (United States)

In this talk, I will demonstrate the existence of an egocentric map prioritizing peripersonal space (PPS) in the rodent rostro-lateral visual area. Analogous to macaque representations in ventral intraparietal and premotor cortices (e.g., Graziano et al., 1997), this PPS encoding responds to visual and tactile cues in a spatially dependent manner. Interestingly, extrapersonal space is also represented, but only when stimuli approach the body, not when they recede. We further demonstrate, for the first time, a single-neuron correlate of a well-established human paradigm for measuring PPS: a visuo-tactile response that is modulated by proximity. These neurons also respond to implied virtual touch. I will describe the cell type specificity, lateral connectivity, and population dynamics of PPS neurons—features not characterized in the seminal macaque work of the 1990s. I will also address whether PPS neurons exhibit multimodal supra-additivity, which has not previously been described. Finally, I will examine how PPS neurons are altered during psychedelic (serotonin-agonist)induced ego dissolution,

providing a first approximation to studying multisensory–motor mechanisms of self-representation at the single-neuron level.

Talk: The development of a hand-centered PPS representation early in life

Rossi Sebastiano Alice (1), Italia Barbara (1), Garbarini Francesca (1)

1 - University of Turin, Turin (Italy)

Compelling evidence shows that multisensory integration (MSI) increases within the space surrounding the body (i.e., peripersonal space; PPS). Thereby, the presence of a spatially organized MSI has been considered a hallmark of bodily-self spatial representation. Previous studies already demonstrated evidence of body-related MSI at birth. We propose that the repeated convergence of multisensory inputs on the hand during early reaching allows the development of a spatially-organized hand-centered PPS. In the present talk, I will present a series of studies in which we first developed an experimental paradigm in adults and then applied it to infants and newborns. In this paradigm, the position of the hand relative to an external object is manipulated to create spatial contingency between multisensory audio-tactile stimuli. Specifically, the postural manipulation consists of moving the hand receiving the tactile stimulation either near or far from a sound-emitting object, thus mimicking the ecological context of early reaching. In the adult sample, results show enhanced MSI responses both at the behavioral (response times) and the neurophysiological (EEG) level when the hand is near the sound source, whereby tactile and auditory receptive fields are brought in register. Crucially, applying the EEG protocol to the developmental sample allowed us to link the emergence of a hand-centered PPS to the early stages of motor development in 3- to 5-month-old infants, when reaching behavior appears. Altogether, these results suggest that motor experience shapes the typical development of a multisensory body representation in space, thus providing a foundation for future investigations in atypical developmental contexts.

Talk: A unified neurocomputational framework for sense of agency and closed-loop motor control

Bertoni Tommaso (1)

1 - École Polytechnique Fédérale de Lausanne (EPFL), Lausanne (Switzerland)

Our sense of self relies on our ability to identify ourselves as independent agents. Sense of agency, the pre-reflexive feeling of generating our actions, is the cornerstone of such process, emerging from the congruency between motor commands and sensory feedback. Like sense of agency, closed-loop motor control relies on the constant integration of efferent commands and afferent feedback. Linking these two aspects would connect a core component of self-representation to a functionally relevant behavior, yet this relationship has not been empirically tested. We hypothesized that the inference of self-causation underlies both sense of agency and sensorimotor integration. Sensory features congruent with motor commands are selectively gated for sensorimotor integration, leading to a sense of agency. To test this, we developed a visuomotor task that simultaneously manipulated sense of agency, by introducing temporal incongruency, and quantified sensorimotor integration, by introducing correctable spatial distortions in visual feedback and measuring the resulting compensation. We found that temporal incongruency similarly affected explicit agency ratings and the amount of sensorimotor integration, and the two were correlated even at fixed incongruency, suggesting a deeper link than mere co-occurrence. These results were captured by a Bayesian model where the brain infers self-causation probability from temporal incongruency, and uses such estimate

to weight visual information during motor control. Using EEG frequency tagging, we found that visual feedback reaches motor areas more in congruent conditions, consistent with a congruency-driven gating mechanism. These results pave the way for a unified neurocomputational framework bridging sense of agency and motor control.

Talk: Peripersonal space as a multisensory interface for self–other distinction and immune defense

Serino Andrea (1,2)

1 - University Hospital of Lausanne (Switzerland)
2 - University of Lausanne (Switzerland)

Peripersonal space (PPS) is a multisensory system whose primary function is to predict potential contact between external stimuli and the body. Our recent work demonstrates that this mechanism can anticipate encounters with potential immune threats, triggering preparatory immune responses. Using virtual reality, we showed that faces displaying signs of infection and approaching PPS are preferentially processed by fronto-parietal multisensory regions together with nodes of the salience network. This coordinated activity is associated with activation of the immune system and the emergence of defensive behaviors. Brain activations are accompanied by altered functional connectivity with the hypothalamus and a distinctive pattern of brain–body signaling involving components of the hypothalamic pituitary–adrenal (HPA) axis. This results in a measurable immune response characterized by activation of innate lymphoid cells. Approaching infected avatars also elicit a freezing-like defensive state, indexed by implicit postural adjustments measured with a stabilometric force platform and changes in heart rate dynamics. This response reflects active threat sampling rather than passive immobility. Accordingly, infected avatars selectively modulate cortico-spinal excitability, assessed with single-pulse transcranial magnetic stimulation over primary motor cortex combined with electromyographic recordings, compared with neutral avatars. Together, these findings confirm the role of PPS as a multisensory interface mediating interactions between the individual and the external environment, enabling a primary form of self–other distinction extending from the skin outward. They further show that PPS predictive mechanisms interact with the immune system, specialized in distinguishing self from non-self within the body, suggesting a unified neurobiological architecture for self-other discrimination across the boundary of the skin.

SYMPOSIUM 3

JUNE 25th | 11:45 am – 1:15 pm

SCIROCCO ROOM

Touch, body, and space: rethinking tactile localization

Fossataro Carlotta, Hoffmann Matej, Fuchs Xaver, Peviani Valeria, Badde Stephanie*

**organizer*

Perceiving and reporting where touch occurs is fundamental and usually intuitive. However, the underlying processes are complex and inherently multisensory, with tactile input constituting only one component of a broader sensorimotor process commonly referred to as tactile localization. This process depends on the integration of multiple information sources related to the current sensory state of the body, including tactile, proprioceptive, and visual signals, as well as stored information about the body and touch, often described in terms of internal body representations or learned priors. Importantly, the spatial localization of touch is not fixed, but flexibly adapts to task demands that define the required behavioral output. Moreover, tactile localization is shaped by experience: it changes with multisensory exposure, sensorimotor feedback, and learning, reflecting the plasticity of the nervous system and the regularities it extracts through interaction with the environment. This symposium aims to show that progress in understanding the spatial perception of touch requires embracing the complexity of its multisensory, task-dependent, and experience-based nature. The contributions address this complexity from complementary perspectives, including body representations and ownership, developmental and sensorimotor mechanisms, methodological analyses of tactile localization tasks, and computational accounts based on prior-driven inference.

Talk: When your body becomes mine: how body ownership gates tactile experience

Fossataro Carlotta (1)

1 - University of Turin (Italy)

The sense of touch plays a crucial role in bodily self-awareness, as the skin constitutes the physical boundary between self and non-self. A large body of research has shown that tactile information contributes to the emergence of body ownership, as elegantly demonstrated by the rubber hand illusion, in which the remapping of the perceived tactile sensation onto a fake hand leads participants to experience it as part of their own body. This supports the view that "I believe this body to be mine because I perceive tactile sensations on it". Here we will address the reverse question: "Do I feel tactile sensations on this body because I believe it to be mine?" To tackle this issue, we adopt a neuropsychological approach focusing on Pathological Embodiment, a striking delusion of body ownership described in brain-damaged patients who misidentify another person's limbs as their own (i.e., E+ patients). After briefly outlining the clinical features and neural underpinnings of the disorder, I will summarize a series of behavioral and psychophysiological studies demonstrating that this body delusion gates tactile awareness, as well as multisensory processing, and self-space representation. Taken together, these findings show that tactile awareness is not rigidly anchored to the physical body, but can be displaced onto another person's limb when it is believed to be one's own. Pathological Embodiment thus reveals that touch is grounded in beliefs about body ownership, providing a unique neuropsychological window into the mechanisms that bind tactile experience to the bodily self.

Talk: From infants to robots: self-touch as a mechanism for learning the sensorimotor self

Hoffmann Matej (1)

1 - Czech Technical University Prague (Czech Republic)

The mechanisms of operation and formation of the body schema or 'sensorimotor self' are largely unknown. Somatosensory information both before and after birth may play a key part in the developmental processes. Specifically, self-touch experience may be a fundamental mechanism to bootstrap the formation of the sensorimotor self. I will present data from infants between 3 and 8 months of age followed longitudinally in three different contexts: spontaneous activity with extracted self-contact statistics, reaching to vibrotactile targets on the body, and reaching to toys. In the reaching to targets on the body paradigm, we additionally compare sighted and visually impaired infants. Next to manually coded behaviors, I will present motion trajectories obtained from video recordings using computer vision methods. By contrasting the behaviors and developmental trajectories in the three contexts and with the help of embodied computational models on humanoid robots with sensitive skin covering their bodies, I will address the following questions: (1) Are infants constructing versatile representations, \"maps\", of their body and space that are then recruited in different contexts or are they developing a \"patchwork of sensorimotor skills\" that is finetuned with? (2) Are selfcontacts events with rich motor-proprioceptive-tactile-(visual) contingencies intrinsically interesting and actively explored by the infants to learn about their body in space? (3) (When) does exploration through self-touch decline and develops into attenuation of self-generated touch known from adults? All behaviors and the corresponding sensorimotor loops are also instantiated in humanoid robots which serve as normative models of the mechanisms studied.

Talk: So what is tactile localization anyway? A review of localization methods

Fuchs Xaver (1)

1 - University of Salzburg (Austria)

Tactile localization is the seemingly simple ability to report where a touch was perceived. However, there are many different ways to assess this ability in research. Given the large variability across studies, it becomes difficult both to define core mechanisms and to compare results, as different methods are likely to engage different sensorimotor and multisensory processes. To obtain an overview of the methodological landscape of tactile localization, we conducted a systematic review of more than 100 studies. We identified key task characteristics that allow current tactile localization methods to be grouped into several distinct classes. These task types differ in their spatial demands and transformations, task requirements (e.g., making decisions versus indicating locations), available spatial references, and the concrete behaviors required from participants. Using selected examples, we pooled experimental data and show that specific methods are associated with characteristic response patterns and biases, indicating that part of the variability across studies may arise from differences in the processes engaged by different localization tasks. Overall, tactile localization is better understood as a family of context-dependent sensorimotor mappings rather than a single, unified process. These findings highlight the need for greater clarity about what different localization tasks measure and how methodological choices shape observed behavior, with important implications for the interpretation of tactile localization research.

Talk: Inferring the body in space: probabilistic representations of limbs and body surface

Peviani Valeria (1)

1 - Donders Institute, Radboud University (The Netherlands)

Localizing touch in space requires integrating tactile signals with information about the current state of the body, including posture, geometry, and the spatial layout of the body surface. This information provides the spatial scaffold within which tactile events are localized across different body regions. Using psychophysics and computational modeling, we have shown that perceptual judgments about the position and geometry of the limbs can be explained by inference on noisy somatosensory signals shaped by prior information. These results indicate that, rather than reflecting a direct readout of somatosensory input, estimates of limb configuration emerge from probabilistic integration processes. Extending this inferential framework beyond limb configuration, we investigated how spatial features of the body surface—specifically the abdomen—are represented and updated. By manipulating multisensory feedback and tracking changes in perception, we show that these representations are dynamically recalibrated rather than fixed. Together, these findings indicate that spatial body features are maintained as probabilistic estimates that are continuously updated in response to incoming sensory evidence.

Talk: Biased representations of touch and the body in space

Badde Stephanie (1)

1 - Tufts University (United States)

Acting upon a tactile stimulus, such as trying to swat a mosquito, requires a spatial representation of the target of the action. This has led to the assumption that tactile representations are remapped into an external, spatiotopic reference frame based on information about the current position of the touched body part. The existence of these external-spatial representations of touch has been derived from the influence of body posture on tactile localization on the body and the human ability to localize tactile stimuli in external space. Using psychophysics and computational models, we have scrutinized both lines of evidence. Our results reveal spatial representations of touch that mirror the default rather than the actual location of the touched limb. These representations can account for body-posture-dependent tactile localization errors and align well with strong biases in hand localization that we and several other labs found. Our results on tactile localization in space, in turn, are well described by a sequential model that combines estimates of tactile stimulus locations on the body with estimates of the location of the touched body part in a biased fashion. In sum, our results speak against an automatic representation of touch in an external reference frame and suggest that biased, heuristic processes enable humans to swat a mosquito (or miss it).

SYMPOSIUM 4

JUNE 25th | 11:45 am – 1:15 pm

PONENTE ROOM

The sensory-motor brain organization and its role in cognition/life

Aggius-Vella Elena, Vaccari Francesco, Monaco Simona, Serino Andrea, Amedi Amir*

**organizer*

This symposium examines how distributed body representations in the brain are constructed and updated through multisensory integration of bodily signals in non-human and human primate model, and how these mechanisms support cognition and plasticity. Body representations are pervasive in the brain. Beyond primary somatosensory and motor cortices, somatotopic or body-part–selective organizations have been described in regions not traditionally framed as sensorimotor. These structures integrate input from different sensory modalities and contribute to functions ranging from action selection to affect regulation. The symposium is organized around 3 main objectives: 1) To highlight body organization beyond primary sensorimotor cortex and its links to proprioception and cognition. 2) To show how body maps in the superior parietal lobule of monkeys and humans integrate sensorimotor feedback with other sensory modalities. 3) To refine mechanistic accounts of sensorimotor–body integration in clinical conditions, with an eye toward intervention targets. Elena Aggius-Vella will provide a focused state-of-the-art on proprioception ("the sixthsense"), summarizing experimental approaches and candidate cortical and subcortical circuits supporting proprioceptive inference and its interactions with vision and touch. Francesco Vaccari will present macaque studies demonstrating distinct somatotopic organizations across parietal regions and how these circuits integrate proprioceptive and visual information to support goal-directed behavior. Simona Monaco will present results on cross-modal modulations of early visual areas during the execution of actions and haptic processing. Michael Akselrod will present data about upper limb representation in primary sensory and motor areas as well in multisensory brain areas, exploring the content and function of these representations in healthy conditions, and when a limb is lost and replaced by prostheses. Finally, Amir Amedi will discuss how digital therapeutics and "hybrid" interventions for mental health and neurodegenerative disease can drive plasticity in circuits that include body-related maps, with emphasis on effects on anxiety, neuro-immune function, and cognitive decline.

Talk: Proprioception as base of embodied cognition

Aggius-Vella Elena (1,2), Bosco Annalisa (1), Amedi Amir (2)

1 - Alma Mater Studiorum, Università di Bologna (Italy)
2 - Reichman University (Israel)

Multiple body representations are mapped across the brain, extending well beyond primary somatosensory cortices. Within an embodied-cognition framework, this sensorimotor organization is not merely supportive of action: it provides information about the body state to shape and scaffold higher cognitive functions such as spatial cognition, communication, and emotion. Proprioception emerges from the integration of multiple receptor systems and is dynamically modulated by multisensory feedback, including vision and touch. It can be viewed as a key interface between body and cognition: the capacity to sense the state of our body and to guide movement in a context-dependent manner. Yet, despite its centrality to everyday behavior, this "sixth-sense" remains

comparatively under-characterized. This talk provides a focused review of proprioception by (i) distinguishing its main functional components: conscious vs unconscious proprioception, (ii) outlining the principal methodological approaches used to measure it from behavioral paradigms to neuroimaging and evidence from neurological disorders and (iii) synthesizing current models of the motor–parietal–cerebellar networks that support proprioceptive processing. Additionally, the presentation and discussion will cover as yet unpublished motor body maps that extend into regions classically associated with emotion and communication. Finally, the discussion will highlight converging evidence that proprioceptive signals contribute to self-related processing, such as agency and body ownership, and predict individual differences in motor learning and spatial performance, pointing to concrete targets for translational paradigms in rehabilitation and human–machine interfaces. The presentation will conclude by proposing a unifying view of how proprioception supports adaptive behavior and cognition through distributed sensorimotor organization.

Talk: Proprioception and vision as the main drivers of superior parietal neurons of non human primates

Fattori Patrizia (1), Vaccari Francesco Edoardo (1), De Vitis Marina (1), Hadjidimitrakis Kostantinos (1), Filippini Matteo (1), Gamberini Michela (1)*

1 - Alma Mater Studiorum, Università di Bologna (Italy)
** speaker*

The superior parietal lobule (SPL)—the medial sector of posterior parietal cortex—is conserved from macaques to humans, making macaque single-unit recordings a powerful route to enrich multisensory computations processes in human. The SPL is not a unitary "association" region, but a mosaic of areas displaying a graded shift from predominantly visual to predominantly somatosensory coding, with proprioception emerging as a key modality for monitoring limb state. Using a classic proprioceptive paradigm (passive limb displacement), we identified distinct body maps across SPL subregions and characterized how these maps interact with vision during action. By manipulating visual feedback in reach-to-grasp behavior, we demonstrated that neighboring SPL areas differ systematically in the strength and format of visuomotor integration. At the caudal end, area V6A responds primarily to upper-limb movement and is strongly shaped by visual information, consistent with a role in guiding reach-to-grasp actions under visual control. More rostrally, PEc shows a stronger dominance of somatosensory/proprioceptive signals and includes responses related to both upper and lower limbs, suggesting a broader role in monitoring limb posture and coordinating movements in relation to the environment. Finally, area PE, adjacent to primary somatosensory cortex, behaves as a high-level somatomotor region with bilateral, multilimb representations, supporting integrative control across effectors. Together, these functional signatures and their anatomical connectivity of V6A, PEc, and PE support a model in which macaque SPL computes body-referenced state estimates. Importantly, human neuroimaging reveals a comparable SPL organization, strengthening the claim that visuomotor integration is a conserved computations in primate parietal cortex.

Talk: A multimodal investigation into the role of early visual areas during hand actions and haptic exploration without vision

Monaco Simona (1), Sartin Samantha (1)

1 - Center for Mind/Brain Sciences, University of Trento (Italy)

The human hand enables goal-directed actions and haptic object exploration, allowing us not only to interact with objects in our surrounding but also to perceive them. Most of the time, we use vision to

guide these processes. Yet, in many situations when visual information is not available, we need to rely on somatosensory feedback to guide our actions. In this talk I will focus on the neural mechanisms of hand actions with a focus on the role of the early visual cortex when visual input is unavailable. In fact, while the existing literature overall agrees on the neural underpinnings of visually guided, skilled hand actions, the brain areas subtending the execution of actions and object exploration in the absence of visual information are still controversial, especially regarding the possible involvement of the early visual cortex. Crucially, it has not yet been thoroughly investigated whether haptic processing in early visual areas might also be functionally relevant for behavior. Overall, this work contributes to our understanding of the neural mechanisms underlying the execution of skilled hand actions and haptic processing of object features in the absence of visual information, particularly addressing the controversial role of early visual areas. These findings indicate that the early visual cortex acts in concert with well-established action-related and somatosensory brain networks. In particular, early visual areas show cross-modal modulations that can be explained within the predictive coding framework, wherein they process haptic and motor-related information to guide behavior even in absence of visual input.

Talk: Plasticity in multisensory representations of the phantom limb

*Akselrod Michel (1), Serino Andrea (1)**

1 - Lausanne University Hospital, Institution of Lavigny and University of Lausanne (Switzerland)
**speaker*

Studying neural changes after amputation and prosthetic replacement offers a powerful window into body representations (BR) and their plasticity, with direct implications for neuroprosthetics. A key goal is to build artificial limbs that are experienced as part of the body—restoring movement while also providing naturalistic multisensory feedback. One non-invasive route is to leverage referred phantom sensations: touch perceived on the phantom limb when stimulating specific sites on the residual limb, creating an intuitive interface between prosthetic sensors and the brain. Many amputees continue to experience a phantom limb, reflecting persistence and reconfiguration of limb representations across sensorimotor systems. Neuroimaging and behavioural work points to heterogeneous plasticity, including differences in representational strength, in which sensory or motor signals engage missing-limb representations, and in how these representations interact with broader sensorimotor networks. Characterizing these patterns is essential for designing training and feedback strategies that promote embodiment and functional use. In this talk, we first describe approaches to map BR content and plasticity across motor, somatosensory, and multisensory cortices. We then present a phantom-limb training platform combining immersive virtual reality with automated tactile stimulation to deliver repeated, temporally congruent visuo-tactile events mapped to the phantom. In an fMRI study (n=8), we mapped cortical phantom-limb representations before and after training and observed experience-dependent plastic changes, including strengthened representational responses and altered coupling with sensorimotor networks. Together, these findings support referred-touch maps as a naturalistic, non-invasive pathway to recruit phantom-limb representations and inform sensory-feedback designs that may improve prosthesis control, embodiment, and acceptance.

Talk: Digital therapeutics and hybrid drugs for Mental Health and neurodegenerative diseases: effects on mood, anxiety, neuro-immune function & cognitive decline

Amedi Amir (1)

1 - Reichman University (Israel)

Digital therapeutics can be designed as mechanism-driven "hybrid drugs": programmable interventions that dose multisensory stimulation together with evidence-based psychological components to reshape brain networks relevant to mental health and neurodegenerative disease. I will frame these effects within embodied cognition and argue that interventions targeting interoception, action, and navigation inevitably recruit systems that contain body-related maps, spanning parietal hubs as well as limbic circuitry. I will first present randomized controlled evidence in adults with subjective cognitive decline (SCD) showing that a structured mobile protocol (RMPY-008) reduces depressive symptoms and anxiety while lowering peripheral pro-inflammatory cytokines, accompanied by connectivity changes in networks linking bodily state, salience, and affect regulation. Second, I will show how multisensory integration can train access to internal bodily signals by externalizing them into controllable feedback. Using an exteroceptive–interoceptive sensory-substitution paradigm that maps respiration onto visual and auditory feedback, participants increased interoceptive sensibility and flow, constructs relevant to emotion regulation. In parallel, I will discuss multisensory enrichment evidence showing that adding touch to auditory stimulation can increase positive mood and reduce state anxiety. Third, I will connect navigation-based training to early cognitive vulnerability, presenting evidence that multisensory virtual navigation in SCD induces perceptual learning and network-level connectivity changes in egocentric/allocentric systems supporting spatial cognition, consistent with engagement of body-referenced computations in occipito-parietal circuits and predictive sensorimotor processing. Across protocols, multisensory integration provides a unifying mechanism that engages distributed body-map circuits and recalibrates sensorimotor inference; intervention ingredients and engagement help link these neural changes to affective and cognitive outcomes.

SYMPOSIUM 5

JUNE 25th | 2:15 pm – 3:45 pm

SCIROCCO ROOM

Perception in action: the role of interaction and behavior in multisensory experience

Peveri Francesca, Gibaldi Agostino, Missoni Fulvio, Guerville Renee, Jahanian Najafabadi Amir Jahanian, Canessa Andrea, Borsani Villa Eleonora**

**organizers*

This symposium brings together complementary contributions that collectively advance a common framework: perception is not a passive decoding of sensory input, but an active and embodied process emerging from continuous interactions between sensory signals, motor behavior, and environmental structure. Rather than merely encoding external stimuli, perceptual experience is dynamically shaped by action, movement strategies, and internal physiological dynamics. Across visual, auditory, temporal, and multisensory domains, the contributions converge on the view that behavior is not simply guided by perception but plays a constitutive role in organizing perceptual experience. Some contributions demonstrate how goal-directed action reorganizes perceptual processing. Active visuomotor engagement reshapes visual sensitivity and cue integration, showing that perceptual learning depends critically on self-generated interaction rather than passive observation. Similarly, precise oculomotor coordination in stereovision reveals how perceptual inference and motor control are jointly optimized to exploit natural scene statistics. Other contributions emphasize movement as a mechanism of perceptual calibration. Head movements during auditory spatial tasks function as active sampling behaviors that maintain stable spatial representations under acoustic uncertainty. At a broader bodily scale, locomotion in multisensory environments regulates sensory flow and temporal structure, illustrating how gait dynamics serve as adaptive perceptual strategies rather than motor outputs. Finally, the symposium extends perception–action coupling to the temporal domain, showing that subjective time emerges from sensorimotor interaction, oculomotor behavior, and physiological rhythms. Spatial engagement, bodily state, and internal dynamics shape temporal experience, linking time perception to embodied action. Together, these contributions span multiple levels of action—from eye movements and head movements to full-body locomotion—and converge on a shared principle: perception is shaped and optimized through action. By integrating psychophysics, behavioral analysis, eye-tracking, physiological measures, and immersive virtual environments, the symposium offers a coherent account of multisensory perception grounded in real-world behavior, with implications for theory, immersive technologies, and rehabilitation.

Talk: Action-driven perceptual learning: from motion sensitivity to cue integration

Peveri Francesca (1), Canessa Andrea (1), Sabatini Silvio P. (1)

1 - Department of Informatics, Bioengineering, Robotics and Systems Engineering University of Genoa (Italy)

Perception is not a passive reflection of sensory input but emerges from an active and reciprocal interaction between the observer and the environment. Through dynamic visuomotor engagement with ambiguous visual stimuli, the perceptual system learns to interpret uncertainty and to flexibly adjust cue integration strategies. This talks present evidence showing how motor interaction actively reorganizes visual perception, influencing both sensitivity and cue integration. In the first study,

participants performed a perceptual task before and after training under three conditions: active (self-generated plaid motion via hand movements), visual-only (observation of another participant's motion), and cognitive (observation with explicit tracking instructions). Only the active group exhibited significant post-training improvements, showing enhanced perceptual integration even when the two gratings differed in contrast. Crucially, changes in perceptual thresholds correlated with systematic changes in movement direction, indicating motor-dependent perceptual learning. Building on this framework, a second study investigated whether action also reshapes the integration of visual cues. Using a two-cue depth paradigm in which disparity and texture conveyed conflicting depth information, we found that active visuomotor interaction with a metameric 3D surface altered the perceived match between cue combinations. Notably, this adaptation emerged without explicit sensorimotor error feedback. Together, these findings demonstrate that action does not merely facilitate learning but directly participates in shaping the internal models through which ambiguous visual input is interpreted, highlighting the central role of action in perceptual learning and visual inference.

Talk: Aligning to see or seeing to align? Stereovision as sensorimotor optimization

Gibaldi Agostino (1), Banks Martin S. (2)

1 - Department of Engineering, University of Modena-Reggio (Italy)
2 - Herbert Wertheim School of Optometry & Vision, UC Berkeley (United States)

Stereovision is often treated as a static perceptual problem in which depth is reconstructed by computing binocular disparities from two retinal images, largely independent of the motor dynamics that generate them. In natural vision, however, stereopsis operates within an active system. Each saccade must be followed by rapid and precise vergence to achieve binocular fusion, accurate depth perception, and prevent diplopia. The visual system must therefore solve, within tens of milliseconds, a coupled problem of eye alignment and disparity processing under strict motor constraints. Perceptually, the visual system is adapted to the statistical regularities of natural scenes: the upper visual field is biased toward far (uncrossed) disparities, and the lower field toward near (crossed) disparities. We investigated the oculomotor counterpart of this adaptation, asking whether binocular coordination is similarly tuned to environmental disparity statistics. Our results show that rapid binocular eye movements are adapted to the three-dimensional structure of natural environments, reducing corrective vergence following saccades. Precise alignment, in turn, reduces the search space for stereo correspondence, facilitating disparity processing. Together, these findings demonstrate that stereovision is not a passive perceptual computation but an active sensorimotor optimization process in which eye movements and perceptual inference are tightly coupled. Perceptual and motor biases thus emerge as complementary adaptations to scene statistics, jointly reflecting the structure of the natural environment.

Talk: Active listening as perceptual calibration in auditory space

Missoni Fulvio (1), Canessa Andrea (1), Picinali Lorenzo (2)

1 - Department of Informatics, Bioengineering, Robotics and Systems Engineering, University of Genoa (Italy)
2 - Dyson School of Design Engineering, Imperial College London, London (UK)

Auditory spatial perception emerges from a dynamic interaction between sensory cues, motor behavior, and environmental structure. Rather than relying on static acoustic information, listeners actively use movement to calibrate and stabilize spatial percepts under uncertainty. In this contribution, we present two studies examining auditory localization as an active perceptual process, focusing on how head movements function as a mechanism for perceptual calibration. In the first

experiment, participants localized sounds in virtual environments with different levels of reverberation (anechoic vs. reverberant), while auditory cues were held constant. Despite comparable localization accuracy across conditions, reverberation elicited more pronounced and structured head movement strategies, indicating that listeners actively adjusted their behavior to preserve reliable spatial perception. The second experiment examined how degradation of auditory cues affects both perception and action. Participants localized sounds using either individualized or non-individualized HRTFs, in anechoic and reverberant environments. Degraded auditory cues led to slower responses and less efficient movement patterns, whereas individualized cues supported faster, more precise head movements and more stable spatial estimates. Together, these results show that head movements are not merely behavioral adjustments but serve as perceptual calibration mechanisms, allowing listeners to actively structure auditory space in challenging acoustic environments. By highlighting the role of active sampling through head movements, this work supports an embodied and ecological account of multisensory perception and emphasizes the importance of considering listening behavior and acoustic context in auditory research and immersive applications.

Talk: Differences in sensorimotor integration in neurodiverse populations across development and sensory environment

Guerville Renee M. (1), El Saheb Lara (1), Yang Fan (1), Seif Ala'a (1), Hare Carolynn (1,2), Chege Marilyn (1), Li Jayden (1), Chen Jeffrey (1), Shrestha Renee M. (1), Segers Magali (1), Stevenson Ryan A. (1)

1 - Department of Psychology, University of Western Ontario (Canada)
2 - Department of Psychology, Carleton University (Canada)

Qualitative reports from lived experiences of neurodiverse individuals (ADHD and Autistic) suggest that their sensory environment impacts sensorimotor integration. Rather than conceptualizing locomotion as purely motor, these self-reports conceptualize changes in movement patterns, including gait, as an active perceptual strategy to respond to and regulate sensory inputs in complex environments. We used a VR environment to manipulate sensory load and rhythmicity. We assessed sensorimotor integration by measuring gait cadence, controlling for cognitive load. Participants included adults and children with ADHD (Ns = 32 and 7, respectively) and Autism diagnoses (Ns=15 and 12, respectively), or neurotypical (Ns=33 and 8, respectively), with data collection ongoing. We observed differences in sensorimotor integration across diagnosis and development. Adults with ADHD showed a greater decrease in cadence in high versus low sensory-load relative to their neurotypical peers. This pattern was not observed in ADHD children. Autistic individuals, across development, did not show significant differences in the effect of sensory load from neurotypicals adults. Entrainment to sensory environment differed by diagnostic group but not age. Autistic and neurotypical participants showed consistent entrainment, but both ADHD groups showed the opposite effect. These findings show that locomotion and movement may indeed function as an adaptive perceptual strategy to modulated sensory inputs, though surprisingly in ADHD more than Autism. In ADHD, moving from a low to a high sensory-load environment prompted a slower cadence, and when that same sensory-load environment is made predictable in the rhythmic condition, gait cadence increases, potentially reflecting an adaptive strategy for managing sensory uncertainty.

Talk: Spatial context and physiological rhythms dynamically shape subjective time perception

Jahanian Najafabadi Amir (1), Kayser Christoph (1)

1 - Department of Cognitive Neuroscience, Bielefeld University (Germany)

Time perception is a fundamental cognitive function supporting essential mental processes such as memory, attention, and decision-making. Rather than being computed independently of action, time perception emerges from sensorimotor and physiological dynamics that actively structure temporal experience. In this talk, we present evidence showing how spatial interaction, bodily state, and oculomotor behavior jointly recalibrate subjective time. In the first study, we investigated how spatial location and the remapping induced by tool-use influence temporal estimation. Using visual time bisection task (2100–2900 ms), we probed the effects of physical and virtual spatial distance (60, 120, and 240 cm). Intervals presented in near space were consistently underestimated relative to far space, revealing a distance-dependent compression of subjective time. Tool-use training expanded peripersonal space boundaries and shifted baseline timing biases, demonstrating that action-induced changes in spatial representation actively recalibrate temporal reference frames. In the second study, we investigated how physiological rhythms, and oculomotor behavior shape time perception across auditory and visual modalities. Blink duration reliably predicted temporal error during time reproduction, while pupil dilation patterns revealed event-specific effects of arousal on perceived duration. Oculomotor behavior actively shapes perceptual timing, as gaze patterns and fixations segment visual input into discrete events that influence temporal continuity. Heart rate variability and respiration further contributed to temporal judgments, with modality-dependent effects. These findings suggest that action, physiology, and eye movements act as endogenous mechanisms that segment sensory input and organize temporal experience. Time perception thus emerges as an embodied and state-dependent process, tightly coupled to sensorimotor and autonomic dynamics.

SYMPOSIUM 6

JUNE 25th | 2:15 pm – 3:45 pm

PONENTE ROOM

Multisensory integration and aging: cognitive, motor, and brain health implications

Newell Fiona, Campos Jennifer, Mahoney Jeannette*, Martinelli Isabella, Marusic Uros, Amedi Amir*

**organizers*

Multisensory integration (MSI) plays a central role in perception, action, cognition, and emotion across the adult lifespan. While age-related changes in unisensory processing are well-established, accumulating evidence suggests MSI changes are not simply secondary consequences of sensory decline. This symposium brings together diverse experimental, neurophysiological, and interventional approaches examining how MSI changes with aging, how these changes relate to cognitive and affective vulnerability, and how compensatory mechanisms may support functional performance. Converging psychophysical evidence will be presented, demonstrating that older adults exhibit altered multisensory temporal processing and illusion susceptibility even when unisensory abilities fall within normal limits. This suggests that MSI measures may capture age-related differences in central integration and cognitive functions that are not detected by standard screening tools. Complementary work examining multisensory body representation reveals age-related distortions in perceived body dimensions and ownership, with impaired proprioceptive precision emerging as a common factor influencing sensory integration needed to support action and self-representation. Other contributions address resilience and compensation within multisensory systems. Despite age-related declines in tactile acuity and sensorimotor precision, haptic object recognition remains largely intact. Evidence from cross-sensory paradigms indicates that visual dominance, top-down modulation, and adaptive integration strategies may compensate for degraded somatosensory input, preserving performance in ecologically relevant tasks. The symposium also highlights links between MSI, brain dynamics, and functional outcomes. Neurophysiological studies demonstrate that individual differences in visual-somatosensory integration are associated with distinct cortical oscillatory activity during balance control, reflecting differences in sensory reweighting and postural stability. Finally, emerging work on multisensory digital interventions reveals that targeting MSI can improve mental health, resilience, immune markers, and functional brain connectivity in adults experiencing subjective cognitive decline. These contributions position MSI as both a sensitive marker of neurocognitive aging and a promising target for interventions aimed at supporting functional independence, emotional health, and resilience in aging.

Talk: Cross-sensory interactions support haptic object perception into late adulthood

Newell Fiona (1), Nevin Kate (1), Camponogara Ivan (2), O'Dowd Alan (1)

1 - School of Psychology and Institute of Neuroscience, Trinity College Dublin (Ireland)
2 - Department of Psychology, College of Natural and Health Sciences, Zayed University, Abu Dhabi (United Arab Emirates)

Recent studies suggest that tactile acuity is linked to cognitive function in older adults, yet how these processes are related is unclear. In everyday interactions, objects are typically explored using vision

and touch leading to rich multisensory representations in memory. We asked whether changes in spatiotemporal sensitivity in touch across adulthood affects this process or if other compensatory factors are involved. First, we found age related differences in the ability to perceive visual and tactile stimuli across time. Specifically, older adults were less prone to a touch-induced flash illusion than younger adults, suggesting that tactile events are poorly resolved in older relative to younger adults. In a second study we aimed to characterise changes in spatial sensitivity in touch with age. We found a clear, age-related reduction in tactile sensitivity, sensorimotor performance, and discrimination of simple features. Moreover, the ability to integrate spatially disparate features over time was reduced in older relative to younger adults when the features were felt but not when they were seen, suggesting visual dominance in feature integration. Surprisingly, despite clear changes in tactile perception across adulthood, haptic object discrimination was generally unaffected by age. In my talk, will discuss the results of our investigations into both top-down and sensorimotor compensatory mechanisms that preserve haptic object perception across adulthood.

Talk: Aging and multisensory integration: independence from unisensory decline and links to cognitive vulnerability

Campos Jennifer (1,2), Montanari Lianna (1,2), Saryazdi Raheleh (1,3)

1 - KITE Research Institute – University Health Network, Toronto (Canada)
2 - University of Toronto, Toronto (Canada)
3 - Trent University Durham, Oshawa (Canada)

Age-related declines in sensory and cognitive abilities are well documented, yet evidence for changes in multisensory integration (MSI) remains mixed. Variability in how sensory and cognitive status are measured and controlled in older adult participants may contribute to these inconsistencies. This talk highlights evidence that MSI can change with older age even when unisensory abilities are within normal limits, and that MSI measures may reveal subtle cognitive variability among older adults who meet standard criteria for healthy cognition. In Study 1 younger and older adults completed audiovisual simultaneity judgement (SJ) and temporal order judgement (TOJ) tasks to assess multisensory synchrony perception. Auditory-only and visual-only SJ tasks were included to index unisensory temporal processing, and standardized assessments of hearing and vision were completed. Compared to younger adults, older adults demonstrated wider temporal binding windows on SJ and TOJ tasks and larger points of subjective simultaneity on TOJ. Importantly, performance on audiovisual tasks was not associated with unisensory temporal measures or standardized sensory metrics. In Study 2 we examined whether susceptibility to the sound-induced-flash-illusion (SIFI) is associated with cognitive performance in older adults with normal vision and hearing who meet criteria for cognitive health. Greater SIFI susceptibility was associated with poorer inhibitory control, working memory, and cognitive flexibility. We will also report on how SIFI susceptibility varies with age-related hearing loss and in individuals at greater risk of cognitive decline (subjective cognitive decline). Considerations will be given to how basic multisensory tasks may be associated with more complex, functional behaviours.

Talk: Body perception in healthy aging - insights from a Psychophysical and Computational Approach

*Risso Gaia (1,2), Martinelli Isabella (1,3)**

1 - School of Health Sciences, HES-SO Valais-Wallis Sion (Switzerland)
2 - Sense innovation and research centre, Sion/Lausanne (Switzerland)
3 - University of Pavia, Pavia (Italy)

*speaker

Introduction: The way we perceive our body and its dimensions depends on how our brain combines information from different senses (Blanke et al. 2015). As the human sensory system declines with age, affecting all sensory modalities (Cavazzana et al. 2018), we hypothesize that body perception may differ between older and younger adults. Methods: We investigate this hypothesis by comparing the experiences of young and older individuals (>65 years) of owning a body (body ownership, BO) and its perceived dimensions (metric body representation, mBR). We applied computational and psychophysical methods to assess alterations in mBR and BO quantitatively. We then modeled the relationship between observed body misperceptions and potential underlying sensorimotor and cognitive factors. Results: The results identified changes in body perception among healthy older adults. They have a distorted sense of their arm dimensions, confirming previous results (Sorrentino et al. 2021, Garbarini et al. 2015). Older adults also tend to feel ownership of an incongruent virtual hand, incorporating it into their motor plans. Impaired proprioception was identified as a common factor affecting different aspects of body experience. Conclusions: Our approach offers new insights into altered body perception during aging, with implications for basic and applied neuroscience, and a broader understanding of neurocognitive aging. In this talk, we will discuss these results and follow-up studies further exploring the relationship between body ownership and proprioceptive abilities in a new sample with a wider age range and extending the investigation of mBR bias in older adults to include the perception of lower limbs.

Talk: Cortical oscillatory signatures of visual–somatosensory integration during balance control in older adults

Bae Jin (1), Marusic Uros (1,2,3), Nunez Valerie (1), Mahoney Jeannette R. (1)*

1 - Stony Brook University, Stony Brook, NY (United States)
2 - Institute for Kinesiology Research, Science and Research Centre Koper, Koper (Slovenia)
3 - Department of Health Sciences, Alma Mater Europaea University, Maribor (Slovenia)
**speaker*

Balance impairments substantially increase fall risk in older adults, and accumulating evidence links these impairments to deficits in multisensory integration, particularly visual–somatosensory integration (VSI). Previous research has demonstrated that greater magnitude of VSI in older adults is associated with better balance performance and reduced fall-risk. While studies often use electroencephalography (EEG) to characterize neurophysiological underpinnings of age-related balance impairments, the extent to which VSI influences balance-related cortical activity in aging remains largely unexplored. In this study, we examined how individual differences in VSI modulate balance-related cortical oscillatory activity. We hypothesized that older adults with greater magnitude of VSI would exhibit frequency-specific cortical signatures characterized by increased frontal theta synchronization and greater alpha and beta desynchronization over sensorimotor, temporal, and parietal regions during sensory-demanding balance conditions, reflecting more effective cortical modulation and sensory reweighting. We further hypothesized that greater frontal and sensorimotor engagement would be associated with reduced postural sway during the Modified Clinical Test of Sensory Interaction in Balance (m-CTSIB). This study included healthy older adults without cognitive impairments. Participants were asked to complete 1) a digital multisensory test (CatchU®) to obtain magnitude of VSI and 2) the m-CTSIB (Biodex Balance System) to assess anteroposterior and mediolateral sway. EEG was recorded concurrently, and relative power spectral density was computed to characterize balance-related cortical oscillatory activity.

Talk: Multisensory integration and aging, how hybrid therapeutics effect cognition and mental health

Amedi Amir (1)

1 - Reichman University (Israel)

Multisensory integration is increasingly recognized as a critical mechanism supporting cognitive resilience, emotional regulation, and brain health across aging. In midlife and older adulthood, subjective cognitive decline (SCD) represents a common and clinically important condition, often preceding neurodegenerative disease. SCD is considered a precursor to neurodegenerative diseases and is more correlated with depressive symptoms than with objective cognitive impairment. Importantly, SCD is strongly shaped not only by memory concerns but also by affective symptoms such as anxiety and depression, which can accelerate cognitive impairment through neuroimmune and network-level dysfunction. In our randomized controlled study, we investigated a three-week mobile digital therapeutic intervention combining evidence-based psychological strategies with multisensory spatial navigation training. Among 103 adults aged 50–65 with SCD and elevated anxiety, the intervention produced significant improvements in mental health, including reductions in depression and situational anxiety, alongside enhanced resilience and well-being, with sustained benefits during follow-up. These psychological gains were accompanied by measurable reductions in peripheral pro-inflammatory cytokines (TNF-α, IL-17, IL-23, MCP-1, IFN-γ, and IL-12), highlighting a potential neuroimmune pathway linking mood and cognition in aging. Resting-state fMRI further revealed enhanced fronto-limbic connectivity, with the insula emerging as a central hub mediating relationships between immune modulation and affective improvement. These findings underscore how multisensory-based digital interventions may promote adaptive brain network reconfiguration while supporting emotional and immune health. Digital therapeutics thus offer scalable approaches to improving cognition and mental well-being in aging populations, with implications for neurodegenerative conditions such as Parkinson's disease and dementia, where affective symptoms are increasingly recognized as integral components of disease burden.

SYMPOSIUM 7

JUNE 26th | 11:45 am – 1:15 pm

SCIROCCO ROOM

Proprioceptive contribution to multisensory body representations and neuroplasticity in normal and pathological contexts

Garbarini Francesca, Bruno Valentina, Bassolino Michela, Radziun Dominika, Bove Marco*, Papaxantis Charalambos*

**organizers*

Proprioception plays a pivotal role in multisensory integration by providing a reference for the construction of body representations. By anchoring multisensory signals to the body, proprioceptive input supports body-centred reference frames. Alterations of proprioceptive processing—congenital, acquired, or experimentally induced—can reshape multisensory integration, with important theoretical and clinical implications. Valentina Bruno will address the contribution of early motor experience to multisensory bodily representation by focusing on children with cerebral palsy. Her work shows that congenital motor limitations impair the capacity of proprioceptive signals to organize sensory information around the body, highlighting cascading effects on bodily selfrepresentation and the relevance of early sensorimotor interventions. Michela Bassolino will examine how disruptions of multisensory integration alter body representations following stroke. She will synthesize evidence of altered limb ownership, body size perception, and abnormal thermal or weight sensations, emphasizing the role of proprioceptive deficits in shaping these disturbances and their implications for assessment and rehabilitation. Dominika Radziun will investigate how artificial body extensions are dynamically integrated into somatosensory representations. Using a wearable finger-extension device and highdensity proprioceptive mapping, her work reveals experience-dependent plasticity affecting biological and artificial fingers across use and removal. Marco Bove will present experimental evidence showing how proprioceptive stimulation via local muscle vibration, alone or combined with action observation, modulates cortical excitability and induces plasticity within frontoparietal networks. Using fNIRS and TMS, his work illustrates how proprioceptive signals can support innovative rehabilitation approaches. Charalambos Papaxantis will focus on the clinical impact of proprioceptive stimulation during the early subacute post-stroke phase, showing that it can limit the development of spasticity and support motor recovery during a critical window for neuroplasticity. Together, these contributions offer a cohesive, multi-level perspective on proprioception as a key mechanism shaping multisensory body representations across development, technological augmentation, and neurological pathology, highlighting its translational relevance for rehabilitation.

Talk: The role of proprioception in multisensory body representation: evidence from cerebral palsy

Bruno Valentina (1), Genovese Francesca (1,2), Piccinini Luigi (3), Garbarini Francesca (1,4)

1 - MANIBUS Lab, Department of Psychology, University of Turin, Turin (Italy)
2 - ISAS, School of Advanced Studies, University of Camerino, Camerino (Italy)
3 - Scientific Institute "E. Medea" Ass. La Nostra Famiglia, Bosisio Parini (Italy)
4 - Neuroscience Institute of Turin (NIT) (Italy)

Spatially organized multisensory integration is considered a hallmark of the bodily selfrepresentation in space. While influential studies have examined how visual development contributes to this representation, motor development has received comparatively less attention. In the present talk, I will present a twofold approach to investigate the role of motor experiences in shaping multisensory representations of the bodily self in space. First, we devised a novel multisensory paradigm that exploits dynamic postural manipulations, allowing to experimentally recreate a spatial contingency between multisensory stimuli through upper-limb movements. In typically developed individuals, results nicely show a body-proximity effect with greater multisensory facilitation when the hand receiving tactile stimulation is moved close to external visual stimuli. Then, we adopted a neuropsychological approach, by exploiting the atypical development of hemiplegic children with cerebral palsy. In this clinical population, a body-proximity effect comparable to controls was found only in the intact side. In the affected side, an altered multisensory representation of the hand in space, as revealed by the lack of body proximity effect, suggests that the deprivation of hand movements since birth has prevented proprioceptive input to anchor multisensory stimuli in a hand-centered reference frame. Importantly, these findings suggest that early motor impairments may have cascading effects on bodily self-representation, underscoring the relevance of early sensorimotor interventions in neurodevelopmental conditions. Novel multisensory approaches, based on the combination of proprioceptive stimulation and movement sonification, will be presented and discussed in the context of cognitive and motor rehabilitation of cerebral palsy.

Talk: Body representation alterations after stroke: the role of sensorimotor impairments

*Konik Stephanie (1), Risso Gaia (1), Martinelli Isabella (1,2), Bassolino Michela (1)**

1 - Institute of Health, School of Health Sciences, HES-SO Valais-Wallis, Sion (Switzerland)
2 - The Sense Innovation & Research Centre, Sion and Lausanne (Switzerland)
** speaker*

Body representations, i.e. internal models that encode and update the state of the body in time and space, emerge from the continuous integration of multisensory information exchanged between the brain and the body during interaction with the environment. When this multisensory flow is disrupted, as frequently occurs in pathological conditions due to sensorimotor impairments or brain lesions, body representations may be compromised. Growing evidence indicates that post-stroke disturbances in body representation extend well beyond classical neuropsychological deficits. Recent studies have described a range of specific alterations affecting different components of body representations. These for instance include disturbances in limb ownership, distortions in the perceived dimensions of body parts, and abnormal perceptions of limb temperature or weight. Such alterations emerge through a variety of quantitative approaches using both explicit measures (e.g. subjective reports) and implicit behavioural paradigms (e.g., tasks probing perceived limb dimension or ownership). In this presentation, we synthesise emerging findings on these multifaceted alterations following stroke. Special emphasis will be placed on the contribution of sensorimotor deficits, particularly proprioceptive impairments, in modulating the presence, severity and variability of these disturbances. A clearer understanding of these phenomena may support the development of more sensitive clinical assessments and inspire innovative rehabilitation strategies. Finally, this perspective may be scalable to other pathological conditions in which sensorimotor impairments may contribute to altered body representations, such as multiple sclerosis.

Talk: The influence of using finger-extending exoskeletons on tactile and proprioceptive localization

Radziun Dominika (1), Geurts Siebe (1), Peviani Valeria (1), Miller Luke E. (1)

1 - Donders Institute for Brain Cognition and Behavior, Radboud University, Nijmegen (The Netherlands)

How does the brain integrate artificial body extensions into its somatosensory representations? Prior work shows that the body and technology are represented simultaneously, but little is known about how these representations evolve dynamically across different sensorimotor interaction phases. To fill this gap, we investigated the dynamics of somatosensory plasticity using a custom-built wearable finger-extension device that elongated users' fingers by 10 cm, spatially augmenting their reachable workspace. Across four time points, before, during (pre- and post-use), and after device wear, participants completed a high-density proprioceptive mapping task to measure representations of the biological and artificial fingers. We observed three distinct phases of plasticity. First, wearing the finger-extension device led to a contraction of the perceived length of the biological finger. Second, after active use, the represented lengths of the biological and artificial fingers stretched significantly, an effect absent when participants trained with a non-augmenting control device. Third, a post-removal aftereffect on the biological finger representation was observed. These results demonstrate that wearable finger extensions that provide spatial augmentation are rapidly integrated into body representations, with dynamic proprioceptive adjustments shaped by structural and functional properties of the device. This work advances our understanding of how the sensorimotor system accommodates artificial extensions and highlights the potential for body-augmenting technologies to be intuitively integrated within the sensorimotor system.

Talk: Combining action observation and proprioceptive stimulation to modulate cortical plasticity: new insights in the field of sensorimotor integration

Bove Marco (1), Iester Costanza (1), Biggio Monica (2), Soldi Elisa (1), Massa Alice (1), Brigadoi Sabrina (3), Cutini Simone (3), Bonzano Laura (4), Bisio Ambra (1)

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2 - Department of Neuroscience, Rehabilitation, Ophthalmology, Genetics, Maternal and Child Health, University of Genoa, Genoa (Italy)
3 - Department of Developmental and Social Psychology, University of Padova, Padua (Italy)
4 - Department of Neuroscience, Rehabilitation, Ophthalmology, Genetics, Maternal and Child Health, University of Genoa, Genoa (Italy)

Numerous studies have investigated how primary motor cortex excitability (M1) can be modulated through external cortical stimulation, peripheral stimulation, and cognitive strategies such as action observation (AO) and motor imagery. The possibility of using a non-invasive technique, namely proprioceptive stimulation (PS), to selectively activate the muscle spindles, even in resting conditions (i.e., in absence of movement), will be demonstrated, highlighting the cortical areas that can be activated through PS. Next, the potential to combine PS with AO (AO-PS) to induce neuroplasticity phenomena will be shown. To address these issues, we will discuss the results obtained using functional near-infrared spectroscopy (fNIRS) to investigate changes in cortical hemodynamic activity within a frontoparietal network during the administration of a novel AO-PS protocol. In this AO-PS protocol, the observed action was aligned with the duration of a spontaneous thumb opposition movement, without being restricted to the conditions required to induce a kinesthetic illusion of movement needing a duration of PS (10s) longer than what typically occurs in a spontaneous movement (about 1s). Furthermore, we assessed whether these neural changes could predict the

effectiveness of the protocol in inducing M1 plasticity, as evaluated by means of transcranial magnetic stimulation, in healthy young adults. Finally, the results of an innovative augmented virtual reality system based on proprioceptive stimulation will be presented and discussed in the context of applications for upper limb rehabilitation.

Talk: Local muscle vibration to prevent upper-limb spasticity after stroke

Papaxantis Charalambos (1,2), Gaveau Jérémie (2), Laroche Davy (2), Julliand Sophie (1,2)

1 - Université Bourgogne Europe, CHU Dijon Bourgogne, Plateforme d'investigation technologique, Dijon, (France)
2 - Université Bourgogne Europe, Inserm, Dijon, (France)

Stroke is a leading cause of disability, with spasticity affecting nearly half of patients early after onset and significantly limiting functional recovery. Local muscle vibration (LMV) has shown benefits in chronic spasticity, but its effects during the early subacute phase (<3 months), a critical window for neuroplasticity, remains unknown. To evaluate the effect of LMV on the development of upper limb spasticity during the early subacute post-stroke phase and to explore associated neurophysiological mechanisms, forty-two (n=42) poststroke participants were randomised to an intervention group or a SHAM control group. LMV was applied to wrist and elbow flexor muscles for 6 weeks. Spasticity was assessed using the Modified Ashworth Scale and isokinetic dynamometry. Motor recovery was evaluated with the Fugl-Meyer Assessment for the Upper Extremity (FMA-UE). Spinal and peripheral excitability were assessed using the H-reflex (Hmax) and M-wave (Mmax), respectively. Assessments were performed before and after the intervention. After LMV, wrist flexor spasticity increased significantly more in the SHAM group than in the intervention group ($p = 0.01$), with a similar trend for the entire upper limb. FMA-UE scores improved significantly more in the intervention group ($p = 0.05$) and were correlated with changes in spasticity. Mmax decreased in both groups and was correlated with motor recovery. Hmax decreased significantly in both groups without a significant between-group interaction or correlations with clinical outcomes. These findings suggest that LMV may limit the development of upper limb spasticity in the early subacute post-stroke phase and support motor recovery.

SYMPOSIUM 8

JUNE 26th | 11:45 am – 1:15 pm

PONENTE ROOM

Navigating sensory uncertainty in motor control: multi-method insights across human and nonhuman primates

Oby Emily, Wilson Taylor, Marneweck Michelle, Davare Marco*

**organizer*

Every goal-directed action depends on sensory information—yet those signals are inherently noisy, delayed, and sometimes misleading. How does the central nervous system (CNS) generate stable, accurate action when the sensory evidence it relies on is ambiguous or incomplete? This symposium brings together complementary cross-method and cross-species work, including brain-computer interface casual perturbations in nonhuman primates, virtual-reality behavioral paradigms, task-based fMRI, and non-invasive brain stimulation in humans, to test how the CNS stabilizes actions when uncertainty is high. Emily Oby will present work using a brain–computer interface to manipulate motor cortical activity during memory-guided reaching. This work tests whether primary motor cortex actively maintains motor working memory under sensory uncertainty. Taylor Wilson will discuss how visually distorted feedback in a bilateral reaching task in virtual reality biases limb symmetry: even with proprioceptive input from both limbs, altered vision strongly shapes motor behavior, although the behavioral shift is smaller than the imposed visual distortion. Michelle Marneweck will present task-based fMRI data consistent with the hypothesis that the CNS handles uncertainty via flexible neural action-goal representations. She will then show that this flexibility diminishes with age, yielding more rigid motor control. Marco Davare uses directional TMS protocols to probe selective intracortical pathways in the primary motor cortex underpinning visuo-haptic integration during performance of skilled hand movements in virtual reality settings. Together, these talks highlight key principles by which the CNS copes with uncertainty, including motor working memory representations supported outside motor cortex, reliability-weighted sensory integration, and flexible parietofrontal action-goal representations that diminish with age. These mechanistic insights identify actionable targets for improving motor performance where sensory information is degraded.

Talk: Interrogating the role of motor cortex in motor working memory

Oby Emily (1)

1 - Queen's University (Canada)

Goal-directed movements must be planned and executed despite uncertainty and delays in sensory feedback. In such conditions, motor working memory is thought to stabilize upcoming actions when sensory information is unavailable or unreliable. During motor planning, activity in motor cortex reflects the upcoming movement, yet it remains unclear whether motor cortex actively maintains motor working memory or instead reflects a memory maintained elsewhere in the sensorimotor network. We tested these alternatives by causally perturbing neural population activity during the memory period of a memory-guided reaching task, a regime in which sensory uncertainty is high. Using a brain–computer interface (BCI), we trained rhesus monkeys to volitionally modulate their neural activity along task-relevant population dimensions that encode the instructed arm reach. We then examined how these perturbations affected the subsequent evolution of neural activity and

behavior. If motor cortex maintains motor working memory, perturbations toward a particular memory state should bias recovery of neural trajectories and the ensuing reach. Instead, we found that the direction of the BCI induced manipulation did not bias the recovery of neural population activity or the eventual reach direction. These results suggest that, under conditions of sensory uncertainty, motor working memory is reinstated by inputs external to the recorded motor cortical population, rather than being autonomously maintained within it.

Talk: Offset vision in virtual reality alters limb symmetry during a bilateral task

Wilson Taylor (1)

1 - University of Oregon (United States)

Virtual reality (VR) has been used to investigate how individuals rely on their senses if given altered visual stimuli but has predominately been applied only to the dominant limb in previous research. This study examined how altered visual feedback affects bilateral limb symmetry during a reaching task in VR. Eighteen participants performed out-and-back arm movements while maintaining symmetry in different blocks, with accurate vision (AV) of the left hand and either AV or forward offset vision (OV) of the right hand at 5cm, 7.5cm and 10cm. Limb asymmetry (LA) at the 10th arm movement was compared across visual conditions. A repeated-measures ANOVA showed a significant effect of block on LA ($p < .001$, $\eta^2 = 0.28$). Post-hoc analyses confirmed that all OV blocks produced significantly greater asymmetry than AV (all $p < .01$, Cohen's $d = 0.69–1.61$), with larger offsets yielding progressively larger LA. These findings indicate that even during bilateral movements with proprioceptive input from both limbs, altered visual information strongly biases motor behavior, though the magnitude of behavioral change is smaller than the visual distortion applied.

Talk: Flexible action control declines with age

Marneweck Michelle (1)

1 - University of Oregon (United States)

Seminal work shows that goal-directed actions are encoded across multiple reference frames in overlapping frontoparietal circuits. This flexible representational architecture likely supports robust control under sensory uncertainty. Prior work suggests the central nervous system handles uncertainty by reliability-weighting sensory inputs, reflected in action-goal representations that depend on cue modality (e.g., visual vs. proprioceptive target information). A key unresolved question is whether this representational flexibility also extends to sensory demands distributed across subtasks within the same action (e.g., signaling when to move vs. where to move). To test this, we combined human fMRI with a visually guided reaching task in which movement-initiation cue were visual or audiovisual. Target-goal representations varied with initiation-cue modality despite comparable behavioral performance, extending evidence that action-goal encoding flexibly adapts to sensory demand across subtasks of the same action. New, unpublished data from our lab suggest that representational signatures of flexible control diminish with age. In a go-before-you-know reaching task during fMRI, younger and older adults initiated reaches from probabilistic cues, with the correct target revealed only after movement onset. Younger adults initiated intermediate reaches under high uncertainty, and flexibly redirected after the target reveal; older adults showed stronger initial directional biases and attenuated neural representations of target likelihood across motor-related regions. These results are consistent with an age-related shift from flexible to more rigid motor control.

Talk: Haptic feedback in virtual reality modulates selective primary motor cortical circuits

Davare Marco (1)

1 - King's College London (UK)

Virtual reality (VR) offers promising avenues for neurorehabilitation, yet most therapeutic VR applications rely solely on visual information and lack haptic feedback during interactions with virtual objects. Haptic feedback, including tactile and proprioceptive inputs, is fundamental for sensorimotor function, in particular for skilled hand-object interactions. Emerging evidence also indicates that multisensory stimuli augment VR experience. Here we investigated whether the presence of haptics during hand-object interactions in VR modulates corticospinal excitability (CSE) through selective intracortical circuits in primary motor cortex (M1). Participants wore a head-mounted VR display and performed brisk index-finger movements to contact virtual objects under four sensory conditions: (1) vision only; (2) vision plus force feedback delivered by a haptic robot; (3) vision plus robotic force feedback combined with touching a real object; and (4) haptic feedback only. To probe CSE within distinct intracortical pathways, we applied directional transcranial magnetic stimulation (TMS) inducing postero-anterior (PA) or antero-posterior (AP) currents in M1. CSE differed significantly across conditions ($\chi^2(3)=22.48$, $p<0.001$). Notably, the vision-only condition elicited markedly lower CSE than all other multisensory or haptic-only conditions, but this reduction emerged exclusively during AP stimulation, implicating selective modulation of late I-wave circuits. These findings demonstrate that haptic feedback recruits specific intracortical pathways likely reflecting cortico-cortical inputs to M1. This highlights the neurophysiological importance of multisensory (visuohaptic) integration for designing VR systems that more effectively engage sensorimotor networks.

SYMPOSIUM 9

JUNE 26th | 2:15 pm – 3:45 pm

SCIROCCO ROOM

Multisensory and sensorimotor-informed tools for early detection and personalized neurorehabilitation

Memeo Mariacarla, Alessandra Sciutti*, Lovotti Maddalena, Sturlese Margherita, Tinelli Francesca, Bergaglio Riccardo, Bodo Giulia*

**organizers*

Multisensory processing and sensorimotor integration are central to how humans perceive, learn and interact with their environment. When these mechanisms are disrupted—due to developmental conditions, brain injury or neurodegenerative processes—difficulties emerge across perceptual, cognitive and motor domains. This symposium brings together five complementary contributions, each illustrating how multisensory-informed approaches and sensorimotor-based technologies can enhance assessment, refine phenotyping, and support targeted rehabilitation across diverse populations. The first contribution introduces visuo-haptic interacting objects as quantitative tools for assessing manipulation skills. By capturing fine-grained multisensory and sensorimotor signatures—such as exploration strategies, coordination and movement quality—these devices offer precise metrics that complement clinical observation and support individualized rehabilitation. The second contribution examines multisensory processing in children with ADHD, showing multisensory behavioural gains but heterogeneous multisensory integration profiles. These findings highlight the diagnostic potential of multisensory markers for refining ADHD phenotyping and guiding personalized interventions. The third contribution presents evidence from multisensory audio-visual telerehabilitation in children with acquired visual field defects, demonstrating improvements in oculomotor compensation, visual detection, daily functioning and potential restorative changes linked to developmental neuroplasticity. The fourth contribution proposes a multimodal technological framework to support early detection of cognitive impairment, integrating cognitive-load monitoring, visuo-haptic tools, spatial-audio paradigms and social-motor music-based systems to capture multisensory functioning in ecologically relevant conditions. Finally, the fifth contribution advances the development of a unified multimodal assessment for robotic-assisted upper-limb rehabilitation, emphasizing how multisensory and sensorimotor metrics can objectively characterize motor recovery and optimize therapy personalization. Together, these contributions articulate a cohesive vision: leveraging multisensory science and sensorimotor integration principles to advance clinical assessment, enrich quantitative profiling and enable more targeted and scalable rehabilitation solutions across neurological and developmental populations.

Talk: Multisensory assessment of manipulation skills with visuo-haptic interacting objects

Lovotti Maddalena (1), Pasquali Dario (1), Antonj Matilde (1), Memeo Mariacarla (2), Bergaglio Riccardo (1), Sciutti Alessandra (1))

1 - CONTACT, Istituto Italiano di Tecnologia (Italy)
2 - EDL, Istituto Italiano di Tecnologia (Italy)

Haptic skills are fundamental to human interaction and underpin the development of cognitive and sensorimotor functions across the lifespan. From childhood to older adulthood, the ability to grasp,

manipulate and explore objects contributes to fine-motor coordination, spatial reasoning and hand-eye integration. These skills are often affected in individuals with motor or neurological conditions—including children with cerebral palsy, patients recovering from stroke or neurosurgical procedures and older adults experiencing age-related decline—highlighting the need for assessment tools that are both sensitive and clinically practical. This contribution presents a multisensory, technology-enhanced approach for the quantitative assessment of manipulation abilities using myCube, a visuo-haptic interactive object. This sensorized device captures rich, non-invasive data on how individuals touch, rotate and explore objects, offering metrics related to movement quality, coordination, exploration patterns and task performance. Its intuitive design, small size and resemblance to familiar everyday objects make it particularly suitable for children and individuals with cognitive or motor challenges, supporting engagement and ecological validity. By integrating tactile, proprioceptive and visuomotor information, this approach provides clinicians and researchers with objective, fine-grained measures that complement traditional observational tools. Such quantitative insights can aid in identifying subtle deficits, monitoring individual progress over time, and tailoring rehabilitation strategies to each patient's sensory-motor profile. The proposed framework represents the core research of the ERC Proof Of Concept project « ARIEL », aiming at developing this sensorimotor visuo-haptic assessment to offer a promising avenue for enhancing the precision, personalization and translational value of clinical evaluation and rehabilitation of manipulation skills.

Talk: The assessment of multisensory profile in children with ADHD

Sturlese Margherita (1), Vitali Helene (1), Gori Monica (1)

1 - UVIP, Istituto Italiano di Tecnologia (Italy)

The impact of multisensory stimulation in children with Attention Deficit Hyperactivity Disorder (ADHD) remains incompletely characterized. Although ADHD is associated with well-documented cognitive alterations, sensory processing—and particularly the integration of auditory and visual information—has received comparatively less investigation. While multisensory gain has been demonstrated in adults with ADHD, developmental findings in children remain limited and inconsistent. We examined multisensory processing in children using an audiovisual oddball paradigm composed of 70% standard and 30% oddball stimuli (10% auditory, 10% visual, 10% audiovisual). Participants responded to oddballs via keypress. Reaction times (RTs) and accuracy were analysed to compare unisensory and multisensory conditions and, performance in the ADHD group was contrasted with an age-matched control group. Both groups exhibited multisensory gain, with faster RTs and higher accuracy for audiovisual compared to unisensory trials. To assess genuine multisensory integration (MSI), we conducted race model analyses. Controls showed reliable violations of the race model inequality, whereas violations in the ADHD group were inconsistent across participants. These findings indicate that although children with ADHD benefit behaviourally from multisensory input, underlying MSI processes may be partially altered. Importantly, a subset of ADHD participants demonstrated clear violations, suggesting preserved MSI mechanisms that may support refined phenotypic differentiation. To support clinical translation, we developed MultTab, a tablet-based tool enabling rapid, standardized MSI assessment. MultTab delivers controlled audiovisual stimuli, records real-time responses and automatically computes MSI indices. Future work will integrate these multisensory profiles with broader clinical data to enhance ADHD subtyping and inform personalized and multisensory interventions.

Talk: Multisensory training with telerehabilitation for brain-damaged children with visual field defects

Tinelli Francesca (1), Baroncini Matteo (1), Tealdi Gessica (1)

1 - IRCCS Fondazione Stella Maris (Italy)

Visual field defects (VFDs) are a common outcome of pediatric acquired brain injury, affecting visuospatial processing, reading efficiency and functional autonomy. Given the heightened neuroplasticity of the developing visual system and the limited extent of spontaneous recovery, targeted rehabilitation strategies are crucial. This study investigates the efficacy of a remotely supervised, home-based multisensory audio-visual training (AVT) protocol designed to strengthen compensatory oculomotor mechanisms and explore potential restorative effects in children and adolescents with chronic VFDs. Participants completed a three-week AVT intervention delivered via telerehabilitation. Outcome measures included visual exploration speed, unimodal visual detection, computerized perimetry, reading performance, vision-dependent activities of daily living (v-ADLs) and affective indices. Behavioural, neuro-ophthalmological and neuroradiological factors were examined as predictors of treatment responsiveness. AVT produced robust improvements in oculomotor visual exploration, with gains maintained through six-month follow-up. Significant enhancements in visual detection were observed both during eye-movement conditions and under fixed-gaze tasks, suggesting the emergence of blindsight-like residual visual processing. Longitudinal perimetry revealed partial visual-field enlargement consistent with activity-dependent plasticity. Additional improvements in v-ADLs and reductions in anxiety demonstrated functional and psychosocial benefits. Predictors of treatment-induced gains included pre-treatment visual search deficits, baseline v-ADL impairment, blindsight performance and microstructural characteristics of the optic radiations. These findings indicate that multisensory telerehabilitation is an effective and scalable intervention for pediatric VFDs, supporting both compensatory oculomotor adaptation and potential restorative changes within reorganizing visual circuits. This work supports the integration of multimodal technologies into neurorehabilitation and illustrates the feasibility of delivering compensatory training remotely while leveraging developmental neuroplasticity.

Talk: Developing a framework to support clinicians in integrating multimodal technologies for early detection of cognitive impairment

Memeo Mariacarla (1), Bergaglio Riccardo (2), Antonj Matilde (2), Pasquali Dario (2), Lovotti Maddalena (2), Sciutti Alessandra (2)*

1 - EDL, Istituto Italiano di Tecnologia (Italy)
2 - CONTACT, Istituto Italiano di Tecnologia (Italy)
**speaker*

Early identification and continuous monitoring of cognitive decline—such as Mild Cognitive Impairment and atypical Alzheimer's disease variants—remain important challenges in clinical practice. Standard clinician-administered assessments are essential and widely validated; however, they are limited to specific domains and may not fully reflect the complexity of cognitive, sensory-motor or social difficulties encountered in everyday life. These constraints become more apparent in populations with heterogeneous disabilities, where symptoms manifest across multiple modalities and contexts. To complement existing diagnostic procedures, we are developing a multimodal, technology-enhanced assessment framework designed to expand clinical insight while supporting individualized care. The system integrates advanced enabling technologies, including cognitive-load monitoring from behavioural and body-language cues, visuo-haptic smart objects (i.e.,

myCube) for evaluating sensory-motor integration, 3D spatial-audio tools (i.e., Audio-Corsi test) for assessing auditory-spatial memory and interactive music-based platforms (i.e., E-Music Box) for measuring social cognition and coordination. Each instrument targets a distinct functional domain, generating high-resolution, quantitative data that enrich the information obtained through traditional evaluations. By combining these tools into a unified, ecologically grounded assessment battery, the framework aims to support clinicians in profiling patients across real-world-relevant tasks, tailoring assessments to disease variants and monitoring mental effort. The system is conceived to be adaptable to diverse populations, including visually impaired individuals and adults with neurodegenerative conditions. Overall, this emerging multimodal technological ecosystem represents a clinically oriented approach that has the potential to improve diagnostic sensitivity, support early intervention and enhance long-term monitoring for individuals with cognitive and sensory-motor disabilities.

Talk: Toward a unified multimodal assessment of robotic-assisted upper limb rehabilitation

Garro Florencia (1), Guanziroli Eleonora (2), Ceroni Indya (1), Bodo Giulia (1), Molteni Franco (2), Semprini Marianna (1)*

1 - Rehab Tech, Istituto Italiano di Tecnologia (Italy)
2 - Ospedale Valduce "Villa Beretta" Rehabilitation Center (Italy)
**speaker*

Motor rehabilitation increasingly relies on assistive technologies to enhance movement execution and promote neuroplasticity. Understanding short-term neuromodulatory and neuromuscular effects induced by such devices is essential for optimizing rehabilitation strategies. In this study, we investigated how a single session of right-arm reaching, performed with and without an assistive device, modulates cortical, muscular and biomechanical activity in healthy adults and persons post-stroke. Thirty-six individuals post-stroke (18 with left-side impairment, 18 with right-side impairment) and a healthy control group were recruited. The Float exoskeleton was used to support arm weight during assisted reaching. High-density resting-state electroencephalography (EEG) was recorded before and after the session. During task execution, upper-limb kinematics, surface electromyography (EMG) and EEG were acquired to characterize movement quality and muscle coordination. Muscle synergies were extracted to evaluate neuromotor organization. EEG spectral power, kinematic parameters, and synergy structure were analysed pre–post intervention. Healthy participants showed increased alpha-band power over right centro-parietal areas, reflecting sensorimotor modulation, whereas post-stroke individuals exhibited a frontal shift in alpha enhancement. EMG and kinematic analyses revealed training-related changes in movement organization. Importantly, post-session muscle synergies in stroke participants became more like those of healthy individuals, particularly in activation timing, suggesting partial restoration of physiological coordination patterns. These findings demonstrate multimodal neuromodulatory effects of assisted reaching. Ongoing work focuses on integrating EEG, EMG and kinematic data into a unified assessment framework to capture motor recovery as a coherent, multidimensional process rather than a collection of isolated measures.

SYMPOSIUM 10

JUNE 26th | 2:15 pm – 3:45 pm

PONENTE ROOM

Illusions as tools to probe the multisensory mind: implications for sensory theory, neuroplasticity, and individual differences

Stiles Noelle, Krisst Lara, Jiang Fang, Sherman Aleksandra, Herzog Michael H., Levitan Carmel**

**organizers*

Illusions are a popular approach to understanding perception, as they can reveal principles by which our minds interpret ambiguous or even conflicting information. Illusory perception has provided consistent breakthroughs in our understanding of sensory dominance, the temporal aspects of integration, and multisensory theory. Historically, illusions such as the Double Flash Illusion showed that audition can dominate over vision on short time scales, and the McGurk Illusion showed the power of visual facial information when interpreting spoken sounds. This symposium presents two talks on novel sets of illusions and then three presentations on the broader implications of illusions on sensory processing. The first presentation will discuss recent novel illusions which have shown that multisensory processing can proceed forward and backward in time within the few hundred milliseconds before consciousness (i.e. Multisensory Postdiction) and that visual blind spot filling-in can be triggered by auditory stimuli (i.e. Multisensory Filling-in) (Stiles et al). In the second talk, the focus will shift to geomagnetic cues – which people may have no conscious awareness of – and their substantial modulation of vision, thereby generating a unique illusory perception (Shimojo et al). The second half of this symposium will address what illusions tell us more broadly. In particular, the variability across older adults in their illusory perception, and how this impacts sensory-motor functionality (Jiang). Talks will also examine individual variability across illusions to argue against a single neurophysiological pipeline or mechanism underlying auditory-visual illusion perception more generally (Sherman et al; Herzog & Yatikci). Comparisons between illusions highlight the uniqueness of the neurophysiology of each, even those within or bridging the same senses differ in occurrence and neural correlates. Therefore, this symposium proposes each illusion as a specific probe into spatial and temporal brain dynamics, and therefore a means to explore how neuroplasticity affects perception in the ever changing perceptual brain.

Talk: The auditory-visual rabbit illusion: multisensory postdiction and filling-in

Stiles Noelle (1), Chan Ailene (2), Cederblad Matilda (2), Levitan Carmel (3), Shimojo Shinsuke (2)

1 - Rutgers (United States), 2 - California Institute of Technology (United States), 3 - Occidental College (United States)

In this talk we will present the Auditory-Visual (AV) Rabbit Illusion, which combines features of the Double Flash Illusion and the Cutaneous Rabbit Illusion. The Double Flash illusion generated illusory visual flashes triggered by sound, indicating that vision can be swiftly and dramatically modified by audition. The Cutaneous Rabbit illusion showed that multiple shifted taps across the surface of the forearm are erroneously perceived to be equally spaced. The AV Rabbit Illusion marries the spatial parameters of the Cutaneous Rabbit with the beep-flash structure of the Double Flash illusion to generate the perception of an illusory flash triggered by a lone beep located between two flash-beep

pairs. The AV Rabbit Illusion showed that information can be transmitted backward in time (i.e. postdictively) within the perceptual processing window before consciousness. This is because the middle illusory flash is perceived to be located between the two real flashes even with a randomized real-flash direction and centrally-located beeps. Postdiction in this particular case is also shown for the first time to bridge the senses (i.e. multisensory). Furthermore, the AV Rabbit Illusion can be positioned on either side of the blind spot, and induce illusory flashes within this small region of blindness. This multisensory filling-in of the blind spot was found to follow multisensory Bayesian integration, which is unexpected given its unique visual processing pipeline. We will also discuss other novel extensions of the AV Rabbit Illusion including its perception with illusory-contour-defined objects.

Talk: Evidence for integration of geomagnetic and visual motion cues in humans

*Krisst Lara (1), Torres Matthew (1), Keyser Bjorn (1), Wu Daw-An (1), Kirschvink Joseph (1), Shimojo Shin (1)**

1 - California Institute of Technology (United States)
**speaker*

Many animals use Earth's magnetic field for navigation, and emerging evidence suggests that humans may also process geomagnetic information. Whether such signals interact with visual perception remains unknown. Here, we tested whether a rotating geomagnetic field can bias human judgments of visual motion perception. Participants sat in a magnetically controlled chamber while viewing a random dot kinematogram (RDK) displayed on a monitor outside the chamber. Motion stimuli were presented at two coherence levels (60% and 0%). On each trial, the background magnetic field either swept slowly from right to left, left to right, or remained stationary. Participants reported perceived motion direction using a twoalternative forced-choice response. In the 0% coherence condition, dot motion was uncorrelated, and responses should therefore be random. However, if the magnetic field provides an implicit reference frame, even non-drifting dots might appear to move opposite the magnetic sweep. Stimuli were presented in three 150-trial blocks: 60% coherence, 0% coherence, and a "sham" control block identical to the 0% coherence condition but without magnetic sweeps. We observed a significant, systematic bias wherein participants perceived motion in the direction opposite to the magnetic field's rotation, even in the absence of actual visual motion signals. We interpret this response as the geomagnetic field providing an implicit spatial reference frame when visual cues are reduced, causing the illusion of opposite motion of visual stimuli when the local magnetic field is rotated. These findings suggest that geomagnetic cues can modulate human visual motion judgments, revealing a previously unrecognized interaction between magnetic and visual reference frames.

Talk: Multisensory illusions and aging

Jiang Fang (1)

1 - University of Reno, Nevada (United States)

Aging is associated with declines in sensory precision, changes in multisensory weighting, and alterations in neural processing that may increase vulnerability to multisensory illusions. These age-related changes have direct implications for balance control, gait stability, and fall risk in older adults. Using the sound-induced flash illusion, we previously demonstrated that older adults with a history of falls exhibited significantly greater illusion strength than older adults without a fall history. Corresponding EEG analyses revealed alterations in oscillatory activity, consistent with a reduction in inhibitory control over sensory processing in fall-prone older adults. Using the McGurk illusion, we more recently examined whether susceptibility to multisensory illusion in older adults is further modulated by individual differences in musical experience, social network properties, and cognitive

abilities. Our findings indicate that older adults with greater musical sophistication and more diverse social networks experience fewer multisensory illusions, suggesting that enriched auditory experience and broader social engagement may support more accurate audiovisual integration in aging. Together, these findings point to modifiable experiential factors that may be leveraged in future intervention studies aimed at improving multisensory integration and functional outcomes in aging.

Talk: Individual differences in multisensory perception of the McGurk effect and the sound-induced flash illusion: evidence from behavior and electrophysiology

Sherman Aleksandra (1), Levitan Carmel (1), Nelli Stephanie (1)

1 - Occidental College (United States)

The sound-induced flash illusion (SIFI) and the McGurk effect are two widely used paradigms for demonstrating powerful interactions between the senses. However, there are substantial individual differences in people's reported experience of these illusory percepts. Our goal was to quantify individual variability for both illusions, assess the stability of individuals' perceptual experience across time, test whether common factors underlie these auditory-visual illusions and explore factors that contribute to variability within sessions. We collected behavioral and EEG data (N= 98) across two separate sessions occurring weeks apart. Although there was robust individual variability across both illusions, illusion susceptibility was stable over time. Critically, there was no correlation between SIFI and McGurk susceptibility. The electrophysiological findings paint a complementary picture. Both illusions were associated with reduced alpha-band power during illusory perception, consistent with the hypothesis that alpha desynchronization reflects enhanced cross-modal integration. However, the illusions diverged in several key respects. SIFI perception was associated with central electrode differences emerging in mid-latency windows, whereas McGurk differences were parietally located and emerged earlier and persisted. Furthermore, the pattern of individual differences differed between tasks: for the SIFI, low-susceptibility individuals showed ERP profiles distinguishable from veridical two-flash trials, whereas for the McGurk effect, group differences were most pronounced during late processing windows. These distinct temporal and topographic profiles align with our behavioral finding that SIFI and McGurk susceptibility are uncorrelated, reinforcing the conclusion that these illusions tap dissociable aspects of multisensory processing rather than reflecting a unitary multisensory integration trait.

Talk: Is there a common factor for illusions?

Herzog Michael H. (1), Yatikci Ece (1)

1 - Laboratory of Psychophysics, EPFL (Switzerland)

Illusions are widely used to investigate the mechanisms of human perception, based on the (implicit) assumption that a common factor underlies these illusions. Accordingly, it is often assumed that results obtained with one illusion, for example the Ponzo illusion, generalize to other spatial illusions. Contrary to this assumption, over the past decade we have shown that illusion magnitudes are strongly correlated within the same illusion and its variants, but show little to no correlation across different illusion types. For instance, an observer who experiences a strong Ebbinghaus illusion does not necessarily exhibit a strong Müller–Lyer illusion. Thus, there is no general "illusion susceptibility" trait across observers. Moreover, when different illusions are experimentally combined, their perceptual effects are largely additive, further supporting the view that distinct illusions rely on separable perceptual mechanisms rather than a shared process. The absence of cross-illusion

correlations cannot be attributed to measurement noise or task unreliability, as illusion strengths are stable across repeated experimental sessions spanning a month. In addition, the results are largely independent of the method used to estimate illusion magnitudes (e.g., 2AFC vs. adjustment tasks). Overall, our findings support a very fine grained account of perception, in which different illusions arise from distinct neural computations operating at different stages of processing.

SYMPOSIUM 11

JUNE 27th | 9:15 m – 10:30 am

SCIROCCO ROOM

Multisensory stimulation and visual rehabilitation

Bolognini Nadia, Reber Michaël, Rowland Benjamin, Cuppini Cristiano*

**organizer*

Visual field deficits following damage to the visual cortex remain among the most disabling and therapeutically challenging consequences of brain injury. Despite the preservation of large portions of visual circuitry, affected regions of space are often considered permanently blind, reflecting a functional silencing of residual pathways rather than their complete destruction. This symposium brings together converging clinical, translational, experimental, and computational evidence that directly challenges this longstanding assumption and positions multisensory integration as a powerful driver of visual rehabilitation. The symposium opens with clinical innovations presented by Nadia Bolognini, demonstrating that audiovisual oculomotor training delivered via telemedicine can produce robust visual improvements in both adult and pediatric patients, and that these effects can be further enhanced through targeted non-invasive brain stimulation of parietal and occipital cortices. Michael Reber then extends this translational framework using immersive virtual-reality-based telerehabilitation, showing that dynamic audiovisual stimulation in ecologically valid tasks can restore visual detection and orientation in children with hemianopia following brain tumors, while offering scalable and accessible rehabilitation solutions. The mechanistic foundations of these clinical effects are addressed by Benjamin Rowland, who provides causal preclinical evidence that multisensory rehabilitation depends on Hebbian plasticity within spared cortical-midbrain circuits. Finally, Cristiano Cuppini integrates these findings within a biologically plausible neurocomputational model, explaining how audiovisual stimulation uniquely drives synaptic reorganization capable of restoring visual and multisensory function.

Talk: New methods of multisensory rehabilitation for hemianopia: from telemedicine to brain stimulation

Bolognini Nadia (1) (2)

1 - Laboratory of Neuropsychology, Department of Neurorehabilitation Sciences, IRCCS Istituto Auxologico Italiano, Milan, (Italy)
2 - Department of Psychology, University of Milano-Bicocca, Milan (Italy)

This presentation will introduce new methods for the rehabilitation of hemianopia using multisensory (audio-visual) stimulation. A clinical study will present the effectiveness and advantages of multisensory oculomotor training carried out at home via telemedicine in adult and pediatric patients with acquired brain injuries (vascular, traumatic, tumor). The potential of applying direct electrical stimulation to maximize the clinical benefits of multisensory training in adult patients will then be demonstrated, discussing the different effects induced by stimulation of the parietal or occipital cortex. Results show that the multisensory training in telerehabilitation can significantly improve function in multiple vision-related domains, the functionality and structural connectivity of the underlying pathways, and the efficiency of multisensory integration. The telerehabilitation version of multisensory training promotes clinical benefits comparable to those of the in-person version. Anodal,

excitatory, tDCS applied to the ipsilesional occipital and parietal areas during the multisensory training increases its behavioral effectiveness, with long-term effects on visual perception in the blind hemifield when the occipital cortex is stimulated, and short-term effects when the parietal cortex is stimulated. Overall, the studies demonstrate is viability of multisensory stimulation in the rehabilitation of visual field deficits and offer new perspectives for its therapeutic use.

Talk: Visual telerehabilitation using virtual reality

Reber Michaël (1)

1 - INSERM UMR-S 1329, Strasbourg (France)
2 - Donald K Johnson Eye Institute, University Health Network, Toronto (Canada)

Visual field loss following pediatric brain tumors - most commonly homonymous hemianopia- constitutes a major and persistent source of neurological disability, with profound consequences for visuospatial perception, educational attainment, mobility, and long-term quality of life. Despite the magnitude of this problem, there is no established rehabilitation intervention capable of restoring visual perception in the affected hemifield in individuals suffering from hemianopia consequent to a pediatric brain tumor. Two recent studies suggest that dynamic audiovisual stimulation based on a 3D object tracking paradigm restores visual detection and orientation in individuals with hemianopia due to pediatric brain tumor. This stimulation is hypothesized to engage covert attentional resources, reinforce subcortical multisensory integration, recruit secondary circuitry and/or reactivate residual visual capacities in the blind hemifield. Performance during audiovisual stimulation significantly correlated with binocular field outcomes, supporting the mechanistic hypothesis of multisensory attentional engagement driving perceptual gains. Together, these studies reinforce a growing body of literature demonstrating that multisensory audiovisual training, particularly in ecologically valid, dynamic tasks such as 3D-MOT in remotely controlled VR, can enhance visual perception more efficiently than traditional static visual training paradigms. They also reinforce the translational advantages of telerehabilitation: reduced clinic burden, equitable access for geographically dispersed patients, and real-time adaptive control of stimulation parameters. Immersive audiovisual 3D-MOT stimulation represents a promising, mechanistically grounded, and clinically scalable approach for visual rehabilitation in pediatric hemianopia.

Talk: Circuits supporting the multisensory rehabilitation of vision

Rowland Benjamin (1)

1 - Dept. of Translational Neuroscience, Wake Forest University School of Medicine, Winston-Salem, NC (United States)

Damage to visual cortex on one side of the brain induces a profound and persistent blindness on the opposite side of space, a debilitating condition that significantly impairs quality of life and functional independence. The level of dysfunction is profound even when other visual circuits in the brain remain structurally intact. Recent work has developed interventions that rehabilitate this blindness using repeated, controlled, and congruent cross-modal (visual-auditory) sensory exposures. Experiments in a preclinical model examine the likely neurobiological bases of this recovery. Physiological recordings from the intact and lesioned brain demonstrate that the sensory exposure paradigm restores neural visual responsiveness by engaging Hebbian mechanisms of multisensory plasticity within interconnected cortical-midbrain circuits physically spared by lesions of visual cortex. Causal methods deployed for circuit disruption in a series of studies demonstrate the importance of both areas in supporting this rehabilitation. Functional deactivation of the cortical area during rehabilitative exposures renders them ineffective. Lesion of the cortical area after a successful rehabilitation reinstates the original blindness. Focal lesions of the midbrain after rehabilitation produce a focal loss

of vision in the rehabilitated field, a novel dependency not seen in the intact brain. Collectively, these results suggest that this rehabilitation procedure, and the vision it restores, depend on this cortical-midbrain axis and its inherent capacity for multisensory plasticity. This provides direct evidence for the crucial mechanisms supporting the ability of this noninvasive sensory exposure technique to ameliorate blindness induced by damage to visual cortex and extend the capabilities of the residual visual brain.

Talk: Explaining the synaptic dynamics underlying multisensory rehabilitation

Cuppini Cristiano (1)

1 - Department of Electrical, Electronic and Information Engineering \"Guglielmo Marconi\" (DEI), University of Bologna, Bologna (Italy)

Hemianopia is a profound blindness in one hemifield caused by extensive damage to the contralateral visual cortex. Empirical data show that a non-invasive multisensory training can restore visual function within a few weeks and suggest that this training induces a functional reorganization within uncompromised visual circuits involving the midbrain. This talk describes a biologically plausible neurocomputational model that explains, at a lower level of abstraction, how synaptic plasticity identified in these circuits can support a functional reorganization that restores visual and multisensory capabilities after damage to visual cortex. In the model, unilateral lesions of the posterior occipital lobe render neurons in higher visual cortical areas and the output layers of midbrain circuits unresponsive to visual stimuli, reproducing hemianopic conditions. The model embeds within the circuits a normalizing Hebbian algorithm previously identified in studies of multisensory development. Auditory-visual stimulation uniquely engages this algorithm in ways that visual and auditory stimulation alone do not. In the hemianopic condition, repeated engagement of the algorithm strengthens residual visual circuits and reinforces a strong functional cortical-subcortical loop involving posterior thalamus, association cortex, and the midbrain. These changes restore visual responsiveness in both higherorder cortex and, consequently, the midbrain. These physiological changes then support the restoration of visually guided behaviors in the formerly-blinded field. The model provides a plausible, comprehensive, and unified neurocomputational framework to explain the empirical findings to date, including the return of visual and multisensory processing, and provides insight into the effectiveness of multisensory-based therapeutic approaches and possibilities for future studies.

TALK SESSIONS

YOUNG RESEARCHER TALK SESSION

sponsored by European Journal of Neuroscience

JUNE 24th | 3:00 pm – 4:15 pm

SCIROCCO ROOM

Chair: John Foxe

Talk #YR.1: Neural correlates of audiovisual gaze-orienting in common marmosets

Cook Tyler (1), Gacoin Maëva (1), Cléry Justine (1)

1 - Department of Neurology and Neurosurgery, McGill University (Canada)

Multisensory integration (MSI), the brains' ability to combine multiple senses, is critical for perception, directing gaze, influencing decision-making, social cognition, language learning, and brain development. Disrupted integration of multimodal signals is implicated in many neurological disorders and produces a large array of cognitive disruptions. To understand MSI and develop therapies for disorders affecting MSI, animal models with human genetic and cognitive similarity are needed. The common marmoset (Callithrix jacchus) demonstrates these traits with a high degree of socialization and communicative vocalization. They have conserved sensorimotor networks, but there is limited information on marmoset MSI functional organization. Understanding marmoset's homology to humans in higher-order associative brain regions is necessary to confirm their relevance as a model of human neurological disorder. I hypothesize that marmosets share MSI attention orienting functionality with humans and macaques arising in the Temporoparietal transitional regions, superior colliculus, and ventral intraparietal area, evident by superadditive responses and distinct functional connectivity and blood oxygen level dependence (BOLD) patterns selective to multisensory stimuli. I examine this with an audiovisual orienting task during task-based functional magnetic resonance imaging, using a non-invasive animal holder and custom MRI coil built for awake marmoset imaging at 7T. I recorded BOLD signal changes using fMRI in response to three spatial orienting tasks, examining stimulus reliability, spatial incongruency, and stimulus onset asynchrony (n = 3). Preliminary data shows increased BOLD activity in marmoset parietal regions PF, PG, and temporoparietal transitional area, including subdivisions of the intraparietal sulcus during multisensory stimulation when compared to unisensory.

Talk #YR.2: Exploring the role of auditory efferences in Eye Movement-Related Eardrum Oscillations

Sotero Silva Nancy (1), Kayser Christoph (1)

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Recent studies described the Eye movement-related eardrum oscillations (EMREOs), low frequency signals recorded in the ear that arise from the tympanic membrane following saccades. We examined data from 31 subjects' comprising bilateral ear recordings and eye tracking to examine effects of

different modulators of the auditory efference system and oculomotor pathways on EMREOs. Outer hair cells (OHC) activity can be suppressed by the medial olivocochlear reflex (MOCR), explicit in the reduction of transient evoked otoacoustic emissions (TEOAEs). If OHCs contribute to EMREO generation, MOCR should reduce EMREO amplitude. We compared EMREO amplitudes by saccades performed in silence and with contralateral noise, which succeeded in suppressing TEOAEs, but did not modulate EMREO amplitude significantly. Second, gravitational cues linked to head orientation may influence saccade planning and, consequently, EMREOs. We therefore recorded EMREOs while participants made saccades in the vertical, horizontal and oblique axis with the head upright and tilted 30° in either direction, assessing temporal and phase consistency across conditions. The mismatch between head and world coordinates shifted saccades distributions, but EMREOs time courses do not reveal significant differences across the tilt conditions. Finally, in two tasks we investigated if judgements of sound locations vary concomitantly with the state of the EMREO by having subjects to perform concurrent visual saccades and a tone lateralization task. Participants accuracy and response time were affected by saccade direction, but not EMREOs magnitude or deflection. EMREOs seem, thus, robust to gravitational cues that influence saccades' execution and top-down cochlear modulations while not altering sound transmission.

Talk #YR.3: Reassessing the Sound-Induced Flash Illusion: a reanalysis of 72 studies and over 150,000 trials

Mittal Jahanvi (1), Parise Cesare (1)

1 - University of Liverpool (United Kingdom)

Sound-Induced Flash Illusion (SIFI) provides a compelling example to investigate the mechanisms underlying multisensory integration. The effect occurs when a single visual flash is accompanied with two auditory beeps and auditory information induces the perception of two illusory flashes. This illusion is determined by the temporal lags used between the flash-beep pair and the second beep which can either precede or follow the other stimuli. Despite the extensive research, substantial variability exists across studies in the reported strength and characteristics of illusion. The present work examines the sources of this variability through a large-scale reanalysis of 72 studies comprising 150,000 trials. Psychometric curves were fitted to the probability of the illusion as a function of temporal lag and two primary measures were examined: the peak illusion probability and width of temporal integration window, reflecting the range of lags over which such audiovisual integration occur. Our analyses show a range effect: broader lag range produce a wider temporal window of integration while reducing the illusion's incidence as reflected by a lower peak probability. Additionally, the auditory intensity affects the peak of the illusion: more intense stimuli, lower probability of illusion and the type of audio presentation (headphones vs speakers) influences both peak and width of the illusion. Taken together, these findings show that even small procedural differences can strongly shape psychophysical estimates, indicating that design choices should be treated as fundamental determinants rather than incidental details. We interpret these results in relation to comparable effects reported recently in multisensory research

Talk #YR.4: Effect of autism spectrum disorder on multisensory integration and sensory sensitivity

Luszawski Michelle (1), Hare Carolynn (2), Shrestha Renee (1), Shannon Julia (1), Li Yuhe (3), Schulz Samantha (1), Stevenson Ryan (1)

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3 - University of Toronto (Canada)

Autistic individuals experience differences in hyper- and hypo-sensitivities to sensory information in multiple sensory modalities, as well as in the ability to integrate sensory information across modalities. Behavioural findings of these differences are not entirely consistent. However, previous imaging studies have shown that even when little to no behavioural differences in multisensory integration are observed, differences in the neural mechanisms underlying integration are still seen. In this study, we examined whether there is an effect of Autism Spectrum Disorder diagnosis on multisensory integration and sensory sensitivity using a speeded response task paired with electroencephalography (EEG) measures. Autistic children (n= 14; 11.6 years, data collection ongoing) and typically developing (TD) children (n= 24; 11.5 years) were presented with auditory pure tones, visual Gabor patches, and a combination of both, all embedded in audiovisual white noise. Participants were instructed to respond as quickly as possible when they detected a stimulus. Stimuli were presented at the participants' unisensory 50% detection threshold, determined via a psychophysical staircase procedure. A small, positive effect of diagnosis on accuracy gain and medium, positive effect of diagnosis on the magnitude of violations of Miller's race model was found. However, preliminary analysis suggests there are neural differences in parietal and occipital regions between the two groups. Additionally, a large, positive effect of diagnosis on behavioural measures of sensory sensitivity was found. Taken together, these results suggest that neural differences for multisensory integration may exist in autistic compared to TD children, even when behavioural performance is well matched.

Talk #YR.5: Evaluation of individual modality-specific cognitive profile: dissociation between objective and subjective measures

Bertolucci Lisa (1), Rauzy Stéphane (1), Abotsi Kossi (1), Pattamadilok Chotiga (1)

1 - Laboratoire Parole et Langage, Aix-Marseille University, CNRS (France)

Characterizing individual differences in multisensory cognition is a key interest in both cognitive and educational sciences. These differences are often described as modality or sensory preference, measured by self-evaluation. However, it remains unclear whether this 'preference' truly reflects the underlying cognitive abilities and sensitivity to different information modalities. To address this issue, we examined individuals' sensitivity to auditory and visual information in four executive functions: working memory, attention, inhibition, and flexibility. We then compared the results of this objective measurement with self-reported learning style preferences, as measured by the VARK questionnaire. Latent profile analysis (LPA) conducted on the objective behavioral measures obtained from 121 participants allowed us to classify them into four classes (see Figure 1) based on the combination of two composite factors identified via Principal Component Analysis: "Cognitive load" (high vs. low) and "Cognitive control" (more efficient in the auditory vs. visual modality). The LPA classification was supported by hierarchical clustering showing high individual-level agreement across the analyses. However, neither profile classification nor continuous cognitive predictors produced the same classification of modality preference measured by the questionnaire. Regularized logistic regression with cross-validation further revealed a dissociation between objective and subjective measures. Although these contrasting findings invite further investigation into the origin of the discrepancies, they highlight the need to distinguish between cognitive-based multisensory profile and subjective preference. Most critically, our novel measure, which targets key executive functions, could provide an alternative to the classic self-evaluation, which has played a dominant role in characterizing individual differences in modality preference.

TALK SESSION 1

JUNE 25th | 9:00 am – 10:30 am
SCIROCCO ROOM

Multisensory body representation

Chair: Laurence Harris

Talk #1.1: Spontaneous eye movements reveal tactile localization on canonical body representations

Gerin Sylvain (1), Andres Michael (1)

1 - Institute of Pyshcological Sciences, Université Catholique de Louvain (Belgium)

Humans constantly move when interacting with their environment. This constant movement complicates the processing of tactile stimuli because localizing tactile input on the body requires considering postural information. According to a well-established view, stimuli are localized on the body based on a representation of the body in its current posture, via a process called tactile remapping. Recently, an alternative view has emerged, arguing that stimuli are localized on a representation of the body in its default posture. We confronted these accounts by recording the spontaneous gaze behavior of participants in response to tactile stimuli on the fingers of their right hand, placed in different postures. With the hand palm-down, the left-to-right direction of gaze shifts reflected the thumb-to- little arrangement of the fingers. Placing the hand palm-up reversed this pattern. Critically, when the hand was placed in a mid-pronated posture, tactile stimuli induced horizontal gaze shifts similar to those observed in the palm-down posture, despite the vertical arrangement of the fingers. Moreover, crossing the right hand to the left of the body shifted the gaze rightward, opposite to the current hand position. Our findings reveal multisensory associations between the somatosensory and oculomotor systems, as tactile stimuli resulted in spontaneous gaze shifts that were not elicited by the task. These tactile- oculomotor associations reveal that tactile localization activates representations of the body in canonical postures, questioning the long-standing view that the current body posture is automatically and continuously computed. Rather, we argue that these computations are not performed if not necessary.

Talk #1.2: Tactile localization along the arm

Khoury Jason (1), Tcaci Popescu Sergiu (1), O'Regan J. Kevin (2), Spisak Josua (3), Hoffmann Matej (4)

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2 - Université Paris Descartes (France)
3 - University of Hamburg, Faculty of Mathematics, Informatics and Natural Sciences (Germany)
4 - Czech Technical University in Prague (Czech Republic)

Reaching to a stimulation on our body, although seemingly simple, requires localizing the stimulus on the skin, transforming that location into a spatial target, and directing an effector to that stimulation. Despite decades of research, this process, tactile localization, remains poorly understood, with open questions about the effect of stimulus duration, anatomical landmarks, and individual differences. We tested 38 participants who localized eight vibrotactile stimuli (200 Hz) spaced along the dorsal forearm and upper arm. Without vision, participants pointed to the perceived location with their right index finger, and 3D errors were recorded via motion capture. We manipulated stimulus duration –

transient (100 ms) versus continuously available – to address a common limitation of prior work. Continuous stimulation yielded significantly better accuracy and precision than transient stimulation, supporting the view that sustained input improves somatosensory localization. Intriguingly, longer time to reach increased error regardless of stimulus duration. Consistent with prior literature, localization variability was highest mid-segment, where perceptual anchoring is weakest, and reduced near anatomical landmarks (wrist, elbow, shoulder). Extending beyond the forearm allowed us to disentangle landmark effects from segment-boundary effects. We also report a systematic constant bias: errors shifted consistently toward the shoulder and overshot laterally. We additionally report preliminary results on how features of motion trajectories differ across conditions and how they relate to localization performance. Crucially, large inter-individual differences in bias direction and magnitude, explained by two bias types, are consistent with the sensorimotor contingency view, which proposes that tactile perception is shaped by idiosyncratic, learned sensorimotor interactions.

Talk #1.3:

Talk #1.4: Investigating the vestibular contributions to body perception when reaching to somatosensory targets

Pitino Jonathan (1), Manson Gerome (1)

1 - Queen's University, Kingston (Canada)

Galvanic vestibular stimulation (GVS) shifts perceived body position, reducing accuracy during reaches to external visual targets. This increase in endpoint error stems from altered multisensory representations of body position in space resulting from the integration of inaccurate vestibular signals. However, it remains unknown whether disrupting vestibular input also biases reaches toward somatosensory targets located on the body itself. Since reaching these targets rely on proprioceptive and tactile cues anchored to body position, vestibular perturbations Additionally, concurrent visual feedback of body position may help compensate for vestibular-induced errors by providing a reliable spatial reference. This study examined the effect of GVS on reaches to a vibrotactile-defined somatosensory target (nose) and whether visual feedback of one's own body reduces vestibular-induced reaching errors. Participants performed reaches with and without visual feedback while bilateral-bipolar GVS induced illusory lateral shifts to the left or right. Analyses of directional error revealed that GVS biased movement endpoints to the direction of stimulation. Contrary to expectations, visual feedback did not reduce GVS-induced endpoint errors. Analysis of reaction times showed significantly slower responses with vision and faster responses during both GVS conditions compared to no-GVS, suggesting that visual input plays a greater role in movement planning when vestibular signals are unperturbed. These findings demonstrate that vestibular disruptions bias reaches toward body-referenced targets and that this bias is not readily corrected by visual input during movement planning.

Talk #1.5: The multisensory correlation detector model explains temporal integration in the rubber hand illusion

Litwin Piotr (1)

1 - University of Warsaw (Poland)

The Rubber Hand Illusion (RHI) demonstrates that body ownership is flexibly constructed in real-time. Since RHI occurrence patterns strongly adhere to key principles of multisensory integration, the illusion can be modeled computationally as an optimal cue integration process. In my presentation, | will outline a novel approach in which RHI occurrence probabilities under different asynchrony conditions are modeled as a function of temporal visuo-tactile correlations with the use of the Multisensory Correlation Detector (MCD) model. | will present the results of three computational simulations that were carried out using data acquired from psychophysical RHI detection experiments. The results of Simulation 1 show that the MCD accounts for observed probabilities in RHI detection tasks, providing comparably excellent fits to empirical data compared to currently dominating Bayesian Causal Inference (BCI) models. However, since MCD is stimulus-computable and thus sensitive to stimulus-driven effects, it has several unique strengths. Simulation 2 demonstrates that MCD predicts visuo-tactile stimulation patternswith complex temporal structures should lead to higher RHI occurrence probabilities, which has been observed empirically, but for which a computational mechanism has not yet been offered. Finally, Simulation 3 shows that MCD relates skewed distributions of RHI occurrence to asymmetrical time constants in early filtering of visual and tactile signals—and thus to individual differences in temporal binding window widths—suggesting a common mechanism for simultaneity and body ownership perception. These findings indicate that the MCD model offers a promising, computationally plausible alternative for advancing our understanding of multisensory mechanisms underlying body ownership.

Talk #1.6: Individual differences in bodily illusions suggest individual differences in causal inference

Fairchild Grant (1), Medina Jared (1)

1 - Emory University, Atlanta (United States)

Differences in experiences of bodily illusions offer a window into individual differences in multisensory integration. Typical bodily illusions are temporally extended processes that require an induction period, yet individual differences in their temporal progression remain largely unexplored. Such differences could reflect different decision strategies individuals use to compute causal inference, as different decision strategies predict distinct patterns of multisensory integration over time. Specifically, different decision strategies should produce time series of proprioceptive drift that asymptote at different levels, asymptote more or less quickly, and have different starting biases. Here, we measured proprioceptive drift over time in both the rubber hand and mirror box illusions across two testing sessions, characterizing individual drift trajectories with parameters for illusion strength, speed, and starting bias. Individual differences in all three parameters were consistent across illusions, suggesting a shared source in fundamental multisensory processing. Parameter estimates were stable across sessions for both illusions, as were questionnaire-based measures of subjective illusion experience. However, questionnaire responses were uncorrelated between the two illusions. This divergence between objective (drift) and subjective (questionnaire-based) measures of illusory experience indicates that they may result from different underlying processes. The differences in the parameters characterizing proprioceptive drift trajectories are consistent with a model where individual differences in preferred decision strategies for computing Bayesian causal inference produce qualitatively distinct patterns of proprioceptive drift that unfold differently over time. If this model is correct, our results suggest that these algorithmic preferences are detectable across multiple illusory contexts and represent stable, trait-like differences.

TALK SESSION 2

JUNE 25th | 9:00 am – 10:30 am
PONENTE ROOM

Multisensory development

Chair: Dorothy Cowie

Talk #2.1: When width and height disagree: development of cross-modal spatial perception

Coelho Lara (1), Sciutti Alessandra (2), Gori Monica (3)

1 - London South Bank University (United Kingdom)
2 - Contact Unit, Istituto Italiano di Tecnologia, Italy (Italy)
3 - Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia (Italy)

Humans rely on both vision and touch to construct spatial representations of objects. During development, these senses are thought to calibrate one another before achieving optimal multisensory integration. However, it remains unclear whether visual and tactile systems use similar spatial cues when estimating object dimensions. The present study investigated whether volume cues influence children's perception of height, and whether this relationship is similar across visual, haptic, and cross-modal conditions. We recruited 38 children between the ages of 3-5 years old and asked them to identify a target block from an array of distractor blocks that varied in height and width. Three stimulus conditions were used: constant (height varied while width remained constant), coherent (height and width increased together), and opposite (width varied inversely with height). The task was completed under four sensory conditions: vision, touch, vision-to-touch, and touch-to-vision. Our results revealed a significant stimulus condition × modality × age interaction. Younger children showed greater difficulty resolving conflicting spatial cues when switching modalities, particularly in the opposite condition where width and height varied in opposite directions. In contrast, older children showed similar performance across coherent and opposite conditions in cross-modal trials, suggesting improved flexibility in integrating spatial cues across senses. Performance was generally better in visual compared to touch conditions regardless of age. Together, these findings suggest that children rely on volumetric cues when estimating object height and that the ability to reconcile conflicting spatial information across modalities improves with development. The results provide further evidence that multisensory spatial representations continue to mature throughout childhood.

Talk #2.2: A comprehensive neurocomputational framework to study the emergence of multisensory perception in the developing brain

Di Rosa Eleonore Federica (1) (2), Astolfi Laura (2), Cuppini Cristiano (1)

1 - Department of Electrical, Electronic and Information Engineering "Guglielmo Marconi" - DEI, Università di Bologna (Italy)
2 - Department of Computer, Control and Management Engineering "Antonio Ruberti" - DIAG, Sapienza University of Rome (Italy)

Multisensory perception emerges through prolonged, experience-dependent reconfiguration of neural interactions; yet most existing accounts typically address either temporal or spatial integration, or focus on isolated behavioural signatures. Here we introduce a comprehensive neurocomputational

framework that, within a single architecture, allows to explain how multisensory facilitation and competition co-develop across time and space and how these changes propagate to decision-level behavior. The model includes auditory and visual modality-specific sensory pathways towards an associative stage that links neural dynamics to overt responses, low-level cross-modal couplings, and inter-areal inhibitory control that implements cross-sensory competition. As these different connectivity mechanisms strengthen and refine via Hebbian-like training thanks to the repeated exposure to uni and multi-sensory stimulation, the proposed network learns to jointly reproduce multiple hallmark phenomena that are usually modelled separately: (i) age-dependent changes in unisensory and multisensory reaction times; (ii) the developmental transition from absent multisensory benefits to robust race- model violations; (iii) the coexistence and maturation of facilitative and competitive cross- modal interactions; and (iv) modality switch effects, emerging naturally from transient inhibitory carry-over. Critically, the trained circuitry generalizes beyond the temporal domain to generate spatial predictions, capturing developmental trends in audiovisual localization precision and systematic biases as a function of spatial disparity and eccentricity. By unifying these diverse mechanisms and behavioural readouts in one biologically grounded mechanistic model, this work provides one of first principled platforms for generating testable hypotheses about how typical development is shaped by sensory experience, and how, in turn, altered experience may lead to atypical multisensory perception.

Talk #2.3: Neural synchronization with audiovisual speech depends on a sensitive period

Fantoni Marta (1), Federici Alessandra (1), Camponogara Ivan (2), Handjaras Giacomo (1), Pavani Francesco (3), Ricciardi Emiliano (1), Pintonello Sara (4), Nava Elena (5), Bianchi Benedetta (6), Debener Stefan (7), Orzan Eva (4), Bottari Davide (1)

1 - IMT AIti Studi Lucca (Italy)
2 - Zayed University, Abu Dhabi (United Arab Emirates)
3 - Centro Interdipartimentale Mente/Cervello – CIMEC (Italy)
4 - IRCCS Materno Infantile "Burlo Garofolo" (Italy)
5 - University of Milan-Bicocca (Italy)
6 - IRCCS Azienda ospedaliero-universitaria Meyer (Italy)
7 - University of Oldenburg (Germany)

Language acquisition relies on biological predispositions and experience with appropriate sensory input during specific developmental windows. Behavioral studies suggested that temporary auditory deprivation during the first year of life can alter the integration of audiovisual speech after hearing restoration through cochlear-implants. However, there is currently no direct evidence demonstrating that the functional development of circuits underlying audiovisual speech integration depends on postnatal sensitive periods. Here, we investigated neural synchronization to continuous auditory (A) and audiovisual (AV) speech in cochlear-implanted (CI) children with congenital (CD = 20) or acquired deafness (AD = 20), as well as in hearing control children (HC = 35). The CD and AD groups differed in exposure to functional hearing during the first year of life. We analyzed neural synchronization to the speech envelope using a multivariate encoding model applied to EEG data and extracted Temporal Response Functions (TRF). Our findings show that speech envelope tracking becomes more efficient with age, reflecting a developmental trajectory in AV speech processing in all groups. Nevertheless, at short timescales of neural tracking (~0–100 ms time-lags), reflecting early processing, AV-TRF was anticipated compared to A-TRF only in HC and AD children, an effect absent in CD group. The data suggest that early auditory deprivation alters AV speech integration despite hearing restoration, highlighting a sensitive period in the first year of life during which AV inputs are critical. Neural

biomarkers in CI children reveal divergent developmental trajectories depending on early auditory experience, offering guidance for tailored interventions.

Talk #2.4: EEG measures of multisensory reading comprehension in autistic children

Hinchey Sarah (1), Newbury Jayne (1), Derrick Donald (1), Theys Catherine (1)

1 - University of Canterbury, Christchurch (New Zealand)

Background: Autistic individuals often experience differences in sensory processing, with up to 90% reporting hyper- or hyposensitivity to stimuli such as sound, light, or pain. Multisensory integration can aid language comprehension but is typically diminished in autism. Reading comprehension is also a documented area of difficulty for many autistic children. Despite a wide range in reading abilities, 62–73% experience challenges. Yet, current teaching strategies in New Zealand often rely on multisensory strategies during reading, like using picture books and reading aloud. Aim: This study investigates whether multisensory reading strategies benefit reading comprehension for autistic children. Methods: We used standardised behavioural assessments and electroencephalography (EEG) in 42 children (22 autistic), aged 8–12 years. The N400 EEG component (300–500ms post-stimulus), a marker of semantic processing, was measured in response to sentence stimuli across three reading modalities: silent reading, reading aloud, and reading with picture supports. Results: The behavioural assessments revealed significant differences between groups only for the vocabulary measure, not for IQ, working memory, or reading comprehension. All participants demonstrated significant N400 effects across conditions ($p < .001$), indicating adequate comprehension. However, autistic children exhibited reduced N400 amplitudes for the picture-supported condition compared to aloud and silent reading ($p = .02$), suggesting decreased reading comprehension when picture supports were present. Conclusions: These findings challenge the assumption that picture-supported strategies universally benefit autistic learners during reading at sentence level. This highlights the need for individualised reading interventions that consider sensory processing profiles, rather than relying on generalised multisensory approaches.

Talk #2.5: Beyond perceptual reports: an EEG-based paradigm to estimate multisensory temporal binding windows in pre-verbal populations

Venturini Camilla (1), Rossi Sebastiano Alice (1), Garbarini Francesca (1)

1 - Università degli studi di Torino (Italy)

Multisensory integration (MSI) is crucial in early development for combining temporally contingent external stimuli into a unified percept, and distinguishing it from segregated events. In adults, the precision of Temporal Binding Windows (TBW), the interval within which cross-modal stimuli are perceived as one, has been linked to Individual Alpha Frequency (IAF), with faster alpha rhythms sampling narrower integration windows. To characterize the development of MSI temporal resolution during the first year of life, we designed an EEG-based frequency tagging paradigm suitable for preverbal populations. Behavioural TBW estimates were first established in adults (N=20) using a modified version of Simultaneity Judgement task with rhythmic audio-tactile stimulation (1 Hz, 0–400 ms SOA). The observed asymmetric TBW (~66 ms for auditory-leading, ~116 ms for tactile-leading conditions) guided the choice of SOA range (0–125 ms) for the EEG study. In the subsequent EEG experiment (N=14), we modelled neural responses, obtained by summing significant harmonic amplitudes, as a function of SOA, applying null, linear, and sigmoidal models. A frontocentral cluster showed superior sigmoidal fitting, with inflection points closely matching individual behavioural TBW,

validating the EEG measure. Resting-state IAF negatively predicted both behavioural and EEG-based TBW, supporting alpha oscillations as the brain's perceptual sampling frequency. These findings established a fully implicit index of TBW that allows us to start data collection in infant populations, were we predict their slower brain rhythms to result in wider MSI temporal resolution, in line with perceptual narrowing accounts.

Talk #2.6: Disrupted top-down modulation as a mechanism of impaired multisensory processing in autistic children

Vanneau Theo (1), Foxe John J. (1) (2), Beker Shlomit (3), Molholm Sophie (1) (2)

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2 - University of Rochester School of Medicine and Dentistry (United States)
3 - Icahn School of Medicine at Mount Sinai, New York (United States)

Atypical sensory processing is a core feature of autism, particularly when integration across sensory modalities is required. The neural mechanisms underlying these multisensory differences remain unclear. We recorded high-density EEG while autistic children aged 8–13 (AU; n=40), unaffected siblings of autistic children (SIB; n=26), and non-autistic controls (NA; n=36) performed a simple reaction-time task to auditory (A), visual (V), and audiovisual (AV) stimuli. Analyses targeted event-related potentials (ERPs; P1/N1/P2), alpha-band event-related desynchronization (α-ERD), and long-range theta-band functional connectivity (weighted phase- lag index, wPLI). Across all unisensory measures (ERPs, α-ERD, and connectivity), groups did not differ, indicating broadly comparable unisensory processing. By contrast, multisensory integration (MSI; operationalized for ERPs and α-ERD as AV – (A+V)) differed across groups: NA children showed significant ERP MSI over parieto-central sites that was absent in AU and SIB; and α-ERD MSI was present in all groups but significantly reduced in AU, with SIB showing an intermediate profile. Connectivity analyses revealed that AV theta-band fronto–parieto- occipital coupling was reduced in autistic relative to non-autistic children, consistent with weaker large-scale coordination during multisensory processing. Together, these results point to a multisensory-specific deficit in autism spanning early sensory encoding, posterior α-ERD, and fronto–posterior coupling. The convergence of results supports a mechanistic account of disrupted multisensory influences on sensory processing due to reduced multisensory attentional orientation. Intermediate SIB profiles suggest inherited liability for these neural phenotypes. These results help explain well-documented behavioral MSI differences in autism by linking impaired early enhancement with attenuated top-down control of sensory cortex.

TALK SESSION 3

JUNE 25th | 5:00 pm – 6:30 pm
SCIROCCO ROOM

Multisensory spatial processing and cross-modal plasticity

Chair: Olivier Collignon

Talk #3.1: Acute central vision loss induces modality-specific destabilization yet promotes shared re-stabilization in spatial localization

Landolfi Lorenzo (1), Kurt Ahmet (1), Tonelli Alessia (1) (2), Domenici Nicola (3), Barbieri Mattia (1), Sabatini Silvio (4), Gori Monica (1)

1 - Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia (Italy)
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3 - Universität Ulm (Germany)
4 - Università degli Studi di Genova (Italy)

Central vision loss is known to reshape spatial representations across senses, yet it remains unclear whether acute visual impairment alters visual and auditory localization through shared or distinct processes. We used a gaze-contingent central scotoma in extended reality to simulate sudden central vision loss in healthy adults (N = 32; mean age = 26.4 years, SD = 5.8) during visual and auditory localization tasks. The induced scotoma disrupted the two modalities differently: visual localization became markedly more dispersed, indicating reduced spatial stability for near-foveal targets, whereas auditory localization showed a consistent outward bias for central sounds, reflecting foveal avoidance, while retaining overall spatial coherence. After the scotoma was removed, both modalities demonstrated location-specific gains in spatial precision compared with controls, especially in regions where uncertainty had been highest during exposure. In vision, these improvements corresponded to a return from instability without surpassing baseline precision; in audition, they produced performance that exceeded baseline. This pattern suggests that such improvement relied on a shared computational principle: developing more resilient spatial strategies under uncertainty, while manifesting differently across senses due to modality-specific architectures. No inward spatial compression emerged within 40 minutes in either modality, diverging from patterns seen in chronic macular degeneration and implying that systematic spatial remapping unfolds over far longer timescales than acute destabilization. Overall, the results show that acute central vision loss (1) affects visual and auditory space differently, introducing instability in vision but coherent reorganization in audition, and (2) triggers a common adaptive mechanism that enhances post-exposure spatial precision across modalities, with implications for cross-modal plasticity and early-stage rehabilitation.

Talk #3.2: Visual context and auditory ambiance shape sound localization and head-movement behavior in immersive VR

Hassani Pouriya (1), Lever Lisa (1), Coudert Aurélie (1), Amat Corine (1), Gaveau Valérie (1)

1 - Université Claude Bernard Lyon 1, CNRS, INSERM, Centre de Recherche en Neurosciences de Lyon (CRNL)(France)

Spatial hearing depends on auditory cues, but is also shaped by visual context and active sensing through head movements. This becomes especially relevant under degraded auditory conditions, such

as in cochlear implant users, where reduced auditory information may increase reliance on visual cues and exploratory sampling strategies. This study examined how visual context influences 3D sound localization and head-movement behavior in normal-hearing adults, while also assessing how acoustic difficulty modulates these processes. Twenty adults performed a 3D sound-localization task using the SPHERE VR setup in a within-subject 3 × 2 design manipulating visual context and acoustic ambience. Visual context conditions were Gray, with no structured visual context, Congruent, with visual structure matching the acoustic environment, and Incongruent, with visual structure mismatching it. Acoustic ambience conditions were NoNoise and Noise. Participants localized real sound sources while immersed in virtual scenes, and both localization responses and head-movement measures were recorded. Visual context significantly affected 3D localization performance, as well as horizontal and depth-related directional biases. Noise primarily affected temporal aspects of behavior, producing slower manual responses, delayed head orienting, and shorter head-movement duration during sound presentation. No significant interaction between visual context and acoustic ambience was observed across outcomes, indicating that the two manipulations acted largely independently. Head-movement findings support the view that active listening contributes to the sampling of both auditory and visual spatial information during localization. Overall, the results show that spatial hearing is shaped by sensory evidence, visual scene structure, and exploratory behavior. They provide a baseline for future studies investigating audiovisual strategies for sound-localization rehabilitation in cochlear implant users.

Talk #3.3: The impact of tactile stimulation in sound source localization

Lever Lisa (1), Hassani Pouriya (1), Amat Corine (1), Gaveau Valérie (1) (2)

1 - Université Claude Bernard Lyon 1, CNRS, INSERM, Centre de Recherche en Neurosciences de Lyon CRNL (France)
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Sound localization in the external space is not only an auditory process, but it is influenced by other sensory modalities. In this study, we investigated if tactile stimulation could facilitate sound localization in normal hearing participants. Using a virtual reality setup, normal hearing participants were asked to localize sounds coming from different azimuths and elevations around them, in both quiet and noisy environment. Three different sensory condition were presented: 1) an auditory-only condition, 2) a condition with a continuous vibration presented during the sound presentation, and 3) an informative tactile condition, in which the vibration intensity varied to indicate the proximity to the sound source. The vibration was delivered to the participants' hand through the virtual reality controller, and they were free to actively explore the space with both head and hand movements during the sound presentation. The results show that tactile stimulation did not directly reduce localization errors. However, several secondary effects suggest potential application for training: tactile stimulation influenced participants' exploration behaviour, triggering different head movements strategies during the exploration phase. Moreover, participants reported greater confidence in the correctness of their response when tactile information was available and rated informative vibrations as more useful than the continuous ones. Overall, tactile information seemed to influence both behavioural strategies and subjective feelings of the participants during sound localization, making this pairing of senses feasible for future training paradigm.

Talk #3.4: The crossmodal nature of touch representation in the human brain: Inter subject correlation revealed shared neural codes for touch and vision.

Castellani Nicolò (1) (2), Simonelli Francesca (2), Bottari Davide (2), Manuello Jordi (1), Liloia Donato (1), Costa Tommaso (1), Cauda Franco (1), Duca Sergio (1), Ricciardi Emiliano (2), Handjaras Giacomo (2), Garbarini Francesca (1)

1 - Università degli studi di Torino (Italy)
2 - Scuola IMT Alti Studi Lucca (Italy)

The tarantula crawling over James Bond's body, or Robert De Niro ordering a hammer- based punishment on a cheat's hand in Casino, are classic cinematic examples of how observing bodily threats on screen can elicit an instinctive physical response, as if the sensation briefly escaped the screen and landed on one's own skin. Feeling a touch and observing one engage distinct sensory channels, yet they appear to share neural representations. Using fMRI and inter-subject correlation (ISC) analysis across modalities, we identified brain regions whose activity synchronizes across individuals experiencing real or observed touch, reflecting common encoding of tactile information. Healthy participants either received continuous tactile stimulation on the digits and dorsum of both hands (Real-Touch) or watched videos of identical hand stimulation (Visual-Touch). ISC analyses revealed synchronized activity across individuals in primary somatosensory cortices, as well as in secondary somatosensory cortices and middle temporal areas. Synchronization decreased when digit identity or lateralization was mismatched, indicating that these representations preserve topographic information. These results demonstrate a crossmodal remapping of touch-related visual input in primary somatosensory cortex. The same experimental protocol has also been applied to individuals with blindness, congenital limb absence (agenesis) and acquired limb loss (amputation). Data analyses from these populations are still ongoing, and preliminary results will be presented at the conference, offering novel insights into crossmodal remapping following altered bodily experience.

Talk #3.5: The neural organization of visual information in the auditory cortex of the congenitally deaf

Tal Zohar (1) (2), Sayal Joana (1) (2), Fang Fang (3) (4) (5), Bi Yanchao (6) (7) (8), Almeida Jorge (1) (2), Fracasso Alessio (9) (10)

1 - Proaction Laboratory, Faculty of Psychology and Educational Sciences, University of Coimbra (Portugal)
2 - Center for Research in Neuropsychology and Cognitive and Behavioral Intervention (CINEICC), Faculty of Psychology and Educational Sciences, University of Coimbra (Portugal)
3 - School of Psychological and Cognitive Sciences and Beijing Key Laboratory of Behavior and Mental Health, Peking University, Beijing (China)
4 - IDG/McGovern Institute for Brain Research, Peking University, Beijing (China)
5 - Peking-Tsinghua Center for Life Sciences, Peking University, Beijing (China)
6 - State Key Laboratory of Cognitive Neuroscience and Learning and IDG/McGovern Institute for Brain Research, Beijing Normal University (China)
7 - Beijing Key Laboratory of Brain Imaging and Connectomics, Beijing Normal University (China)
8 - Chinese Institute for Brain Research, Beijing (China)
9 - School of Neuroscience and Psychology, University of Glasgow (United Kingdom)
10 - Department of General Psychology, University of Padua (Italy)

Neuroplasticity is the brain's ability to reorganize its structural and functional architecture throughout life. In congenital deafness, the sensory-deprived auditory cortex can be recruited to represent sensory information belonging to other modalities, a process known as cross-modal plasticity. Previous studies have indicated that the auditory cortex of congenitally deaf, but not of

hearing individuals, is recruited during visual tasks. However, it remains unclear whether and to what extent these cross-modal responses represent low-level visual spatial information or map the visual field. Here, we addressed this question using two complementary fMRI experiments focusing on cross-modal processing in the auditory cortex of both deaf and hearing individuals during passive viewing of conventional visual stimuli. The first experiment, at the group level, revealed that, unlike in hearing individuals, the auditory cortex of deaf individuals predominantly exhibited negative BOLD signals in early and associative auditory areas—a surprising finding given the prevailing focus on activations in prior work. These negative BOLD signals— commonly interpreted as deactivation responses—suggest that visual information may be represented via cross-modal deactivation mechanisms. We complement the investigation with an exploratory follow-up analysis using pRF modeling in a subset of participants. Together, our findings indicated that, in congenitally deaf individuals, cross-modal visual processing in the auditory cortex may be mediated by deactivation signals, offering new insights into the neural basis of sensory reorganization.

Talk #3.6: Underlying neural mechanisms of multimodal information processing: the case of Visual Word Form Area's responses to speech

Pattamadilok Chotiga (1)

1 - Laboratoire Parole et Langage, Aix-Marseille University, CNRS (France)

Reading acquisition is a prime example of audio-visual association learning. At the neural level, the development of this skill progressively turns neurons in a specific part of the left ventral occipito-temporal cortex sensitive to written language, giving rise to the Visual Word Form Area (VWFA). Interestingly, despite its location within the visual pathway and its central role in reading, the VWFA also responds to speech. This cross-modal activation raises a critical question: How do neurons within the visual system respond to auditory input? To address this question, we employed within- and cross-modal repetition suppression paradigms using three complementary brain-imaging techniques: transcranial magnetic stimulation, fMRI and stereotactic electroencephalography. Our converging findings reveal that this 'reading area' contains not only neurons that respond to written input but also those directly activated by speech. In other words, the cross- modal responses likely arise from two complementary mechanisms, i.e., activation of visual neurons through the conversion of speech sounds into visuo-orthographic representations, and direct activation of spoken language-coding neurons by speech input. The second mechanism invites further investigation into the impact of reading acquisition on brain functional reorganization and the origins of the VWFA. One possibility is that the spoken language-coding neurons in this brain region emerge through intensive audio-visual association learning during reading acquisition, reshaping the function of the visual pathway. Alternatively, these neurons may predate reading acquisition, thereby predetermining the VWFA's location as literacy develops.

TALK SESSION 4

JUNE 25th | 5:00 pm – 6:30 pm

PONENTE ROOM

Computational approaches to multisensory processing

Chair: Marc Ernst

Talk #4.1: Begging the body: Bayesian causal-inference does not explain body ownership

Lenti Matteo Mauro (1)

1 - Università degli studi di Torino (Italy)

This paper contends that existing Bayesian Causal Inference (BCI) models do not yet explain how the sense of body ownership (SBO) arises from multisensory integration, because they treat as primitive assumptions the very components that a satisfactory explanation ought to ground. Most of the literature agrees that SBO is rooted in multisensory experience trough integrative binding. (Vignemont, 2018). However, how multisensory integration gives rise to SBO remains a matter of ongoing debate. The dominant framework for understanding this integration mechanism is the BCI (e.g. Chancel et al., 2022; Fang et al., 2019; Samad et al., 2015), which claims that the emergence of SBO toward an object is the result of a common-cause inferential process. Prior expectations are required in order to fulfil this aim. However, their role in Bayesian-inspired models has often raised concerns in the critical literature. This paper offers a critical argument targeting the role of such expectations in explaining how the SBO emerges. First, I argue that the Bayesian explanation is circular, because the expectations it invokes already presuppose SBO. Second, I contend that prior expectations are explanatorily unstable, insofar as they display features that make systematic investigation difficult: (1) Black-box problem (Craver, 2006); (2) Homunculus problem (Margolis, 1980); (3) Interface problem (Burnston, 2021); In light of these difficulties, the paper argues that BCI models fall short of explaining how SBO arises from multisensory integration, because the decisive explanatory work is effectively offloaded onto the model's background assumptions—above all, explanatorily unstable prior expectations.

Talk #4.2: Causal inference in the robotic hand illusion

Rohe Tim (1), Bliek Adna (2) (3), Andreas Daniel (3), Beckerle Philipp (3)

1 - Institute of Psychology, Friedrich-Alexander-Universität Erlangen-Nürnberg (Germany)
2 - Social and Intelligent Robotics Research Laboratory, University of Waterloo (Canada)
3 - Chair of Autonomous Systems and Mechatronics, Friedrich-Alexander-Universität Erlangen-Nürnberg (Germany)

Humans perceive their body by integrating visual, tactile, and proprioceptive signals into a coherent body representation. Remarkably, this sense of embodiment can extend beyond the biological body when multisensory signals from external objects, such as prosthetic or robotic hands, are integrated into the body representation, giving rise to the "robotic hand illusion". Here, we examined whether and how the embodiment of a robotic hand follows the principles of Bayesian Causal Inference (BCI), which posits that multisensory signals are integrated only when a common cause is inferred, such as one's own body. Participants actively moved a robotic hand using a sensor glove during an induction phase. We then assessed proprioceptive drift (the perceived shift of one's own hand position toward

the robotic hand) and ownership ratings as indices of embodiment. Across two experiments (n = 31, n = 34), we manipulated spatial disparity between real and robotic hands, visuomotor synchrony during movement, the site of haptic feedback (finger vs. forearm), and the haptic feedback's visuotactile synchrony. Results revealed that the robotic hand was partially embodied within a limited spatial window when visuomotor signals were synchronous. Synchronous haptic feedback further enhanced embodiment, independent of its location, and embodiment strength increased with continued use, suggesting adaptation. A computational BCI model accurately captured the observed patterns, indicating that embodiment arises when participants infer a common cause for sensory signals. These findings highlight causal inference as a key mechanism underlying robotic embodiment, which may inform the design of more intuitive prosthetic and assistive devices.

Talk #4.3: Offloading or interfering? Social effects on causal inference in multisensory integration

*Wahn Basil (1), RahIf Martje (2), Rohe Tim (2)**

1 - Technical University of Berlin (Germany)
2 - Friedrich-Alexander Universität Erlangen-Nürnberg (Germany)
**speaker*

Humans continuously receive information through multiple sensory modalities, which the brain flexibly combines into unified percepts via multisensory integration. Because perception often occurs in social settings, recent research has examined how social context shapes this integration process. Prior studies showed that when two people perform complementary spatial tasks (i.e., each responding to a different sensory modality) task-irrelevant stimuli can be socially offloaded to the partner, reducing crossmodal distraction. However, these tasks were performed in parallel without a joint goal, leaving open how joint goals influence integration. To address this gap in the literature, in the present study dyads performed an audiovisual spatial localization task in which each person responded to one modality but followed a joint goal by coordinating response onsets. Compared to a solo and passive social control conditions (i.e., where the co-actor had no task to perform), joint goal coordination increased multisensory integration, indicating co-representation of the co-actor's stimuli, in contrast to earlier findings. Computational modeling revealed that this effect was best explained by increased auditory sensory variance which reflected reduced auditory weighting and extended the spatial integration window, rather than changes in the causal prior or perceptual decision strategies. Together, these findings suggest that multisensory integration flexibly adapts to social task structure (i.e., whether a joint goal is present or absent), underscoring the need for computational models to incorporate a social dimension.

Talk #4.4: Scikit-NeuroMSI: a generalised framework for modelling multisensory integration

Paredes Renato (1), Cabral Juan (2) (3), Seriès Peggy (4)

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2 - Grupo de Innovación y Desarrollo Tecnológico, Gerencia De Vinculación Tecnológica, Centro Espacial Teófilo Tabanera, Comisión Nacional de Actividades Espaciales (CONAE) (Argentina)
3 - Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina)
4 - School of Informatics, University of Edinburgh (United Kingdom)

Multiple theoretical models exist to account for the computational processes behind multisensory integration. However, researchers in the field lack a consolidated framework that facilitates the

examination of multisensory integration across diverse experimental and computational contexts. We introduce Scikit-NeuroMSI, a Python-based open-source framework designed to streamline the implementation and evaluation of computational models of multisensory integration. The capabilities of Scikit-NeuroMSI are demonstrated by the implementation of multiple models of multisensory integration at different levels of analysis. Furthermore, we illustrate the utility of the software in systematically exploring the model's behavior in spatiotemporal causal inference tasks through parameter sweeps in simulations. We conduct a comparative analysis of Bayesian and network models of multisensory integration to identify commonalities that may enable to bridge both levels of description. We discuss the significance of this framework in generating computationally informed hypotheses in multisensory research. Recommendations for the improvement of the software and directions for future research using this framework are presented.

Talk #4.5: Phoneme overlap analysis of the visual benefit for speech-in-noise perception

Magnotti John (1), Zhang Yue (2), Zhu Lin (3), Yu Yingjia (4), Beauchamp Michael (1)

1 - University of Pennsylvania (United States)
2 - Baylor College of Medicine (United States)
3 - University of Texas Southwestern Medical Center (United States)
4 - University of Pittsburgh (United States)

Seeing the face of the talker improves the intelligibility of speech embedded in auditory noise, termed the visual benefit. The visual benefit is usually measured at the whole-word level, with responses classified as "correct" or "incorrect". An alternative method measures visual benefit using the phoneme overlap between stimulus and response. In 55 participants presented with auditory and audiovisual words, phoneme-overlap analysis estimated 289 different visual benefit values, compared with only 3 different values for whole-word analysis. Phoneme-overlap detected a positive visual benefit in 67% of word-participant pairs, in contrast to 32% for whole-word analysis. Individual words varied greatly in their phoneme- overlap visual benefit, from 1% to 72%. Variability across words could be accurately modeled (r = 0.78) by the phoneme composition of the word and the visual benefit for untested words could be predicted with a median error of 9%. We also measured the visual benefit for individual phonemes with signal detection theory. Five phonemes showed a particularly large visual benefit, with audiovisual sensitivity (d') of 3.7. The increased sensitivity of phoneme-overlap analysis relative to conventional whole-word analysis may provide a useful tool for investigations of audiovisual speech perception in clinical, neuroscience and computer science applications.

Talk #4.6: Development of multisensory decision-making: from unisensory dominance to reliability-weighted integration

Diaz Jessica Ann (1), Kyriakos Birmpas (2), Andrews Mark (3), Campus Claudio (4), Gori Monica (4), Delis Ioannis (5)

1 - Birmingham City University (United Kingdom)
2 - University of Cambridge (United Kingdom)
3 - Nottingham Trent University (United Kingdom)
4 - Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia (Italy))
5 - National Technical University of Athens (Greece)

Multisensory decision-making (MSDM) allows the brain to combine information from multiple sensory modalities to guide behaviour. Although adults integrate sensory evidence in a statistically optimal, reliability-weighted manner, the developmental timeline and computational mechanisms underlying

the emergence of optimal multisensory decisions remain poorly understood. Here, we investigated how MSDM evolves across childhood and adolescence using a large behavioural dataset (N = 123) spanning three age groups (5–8, 9–12, and 16–21 years). Participants performed a rapid face-versus-car categorization task using noisy visual, auditory, and audiovisual stimuli while both reaction time and accuracy were recorded. To characterize the computational processes underlying performance, we combined Bayesian ideal-observer modelling of sensory reliability with hierarchical drift–diffusion modelling (HDDM), allowing us to dissociate changes in sensory encoding from decision-stage evidence accumulation. Results revealed a clear developmental transition between childhood and adolescence. Young children showed strong unisensory dominance and no reliable audiovisual advantage relative to their best unisensory modality. In contrast, adolescents and young adults exhibited robust multisensory facilitation driven by increased drift rates during audiovisual trials, indicating faster evidence accumulation. Reliability analyses further showed that cue weighting progressively approached the predictions of optimal Bayesian integration, with the transition occurring around 9–12 years of age. These findings demonstrate that mature multisensory decision-making emerges through a developmental shift from imbalanced sensory encoding to reliability- weighted evidence accumulation. By combining computational modelling with behavioural analysis, this study provides a mechanistic account of how optimal multisensory decision processes emerge during development.

TALK SESSION 5

JUNE 26th | 9:00 am – 10:30 am
SCIROCCO ROOM

Active sensing and sensorimotor integration

*Chair: Alessandro **D'Ausilio***

Talk #5.1: Multisensory number channels derived from individual differences

Burr David (1), Petrizzo Irene (1), Arrighi Roberto (1), Cicchini Guido (2), Anobile Giovanni (1)

1 - Università degli Studi di Firenze (Italy)
2 - Consiglio Nazionale delle Ricerche, Pisa (Italy)

A few seconds of adaptation by finger-tapping changes the perceived numerosity of spatial arrays and of temporal sequences of visual objects displayed near the tapping region, implying the existence of a multimodal sensorimotor numerosity system. Here we reinforce this evidence with a well-established individual-difference technique, exploiting the fact that discriminability of stimuli processed within the same mechanism should be more correlated between individuals than stimuli processed by different mechanisms. Participants pressed rapidly a key a specific number of times, displayed digitally on each trial. Reproduction precision was highly correlated between participants when target numbers were similar, scaling down with numerical distance (Fig. 1a), implying tuning selectivity. In the same participants, we measured precision in estimating temporal numerosity (sequences of flashes) and spatial numerosity (arrays of dots), together with production of actions. Correlation within each task showed tuning selectivity. Cross-task correlations suggested shared tuning between the sensorimotor and temporal visual numerosity (Fig. 1b), pointing to channels responsible for performance in both visual and motor temporal number tasks. However, there was no shared tuning between spatial visual numerosity and the other two tasks (Figs. 1c,d), suggesting partially different patterns of encoding for temporal and spatial numerosity, and that only temporal numerosity mechanisms are linked to numerosity of action. We will discuss these results in the light of our recent demonstration of the strong correlation between action reproduction and math skills in school-age children, implicating the sensorimotor numerosity system in acquisition of maths.

Talk #5.2: Incidental learning from unimodal and multimodal associations

Roark Casey (1)

1 - University of New Hampshire (United States)

Humans can learn novel auditory categories incidentally by learning associations between sound categories and behaviorally relevant visual information. For example, in one task, learners hear sounds whose category perfectly predicts the location of a visual target (Figure 1A). Participants are not told anything about the sounds – they simply respond based on the location of the target. Through these auditory-visuomotor associations, learners incidentally acquire the sound categories. We address two unanswered questions. 1) Can humans incidentally learn visual categories from audiomotor associations? 2) Is the multimodal nature of this task critical to learning? In Experiment 1, participants (N = 53) completed a simple task in one modality (auditory – click on one of four boxes indicated by a voice; or visual – click on the box containing a red X) that was incidentally associated with category information in another modality (visual - Gabor patches; or auditory – spectrotemporal ripples).

Participants incidentally learned the categories in both modalities – reaction times were slower when the association was destroyed and participants accurately categorized stimuli in a post-test. Mousetracking analyses indicated that learners increasingly used seemingly task-irrelevant modality information to facilitate responses throughout the primary task. In Experiment 2, participants (N = 107) completed the same tasks, but category associations were either multimodal or unimodal. Participants demonstrated successful incidental learning from both unimodal and multimodal associations (Figure 1B). Together, these results demonstrate that humans can incidentally learn both auditory and visual categories from unimodal or multimodal associations, highlighting the flexibility of incidental learning mechanisms.

Talk #5.3: Tactile modulation during movement

Fiehler Katja (1)

1 - Justus Liebig University Gießen (Germany)

Movement planning and execution lead to changes in tactile perception. For example, tactile stimuli on a moving compared to a resting limb are typically perceived as weaker. This phenomenon is termed tactile suppression and has been linked to a forward model mechanism which predicts the sensory consequences of self-generated actions and as a result discounts the respective sensory re-afferences. As tactile suppression is also evident in passive hand movements, both predictive and postdictive mechanisms may be involved. Tactile suppression is not an all-or-nothing process, but is modulated depending on the task requirements. If tactile feedback from the moving limb is needed to acquire information, e.g. during manual exploration or object grasping, tactile sensitivity is less strongly reduced. In my talk, I will present recent results from psychophysical and electrophysiological (EEG) experiments in which we probed tactile suppression at different time points shortly before or during a reaching movement. We found that tactile sensitivity is dynamically modulated during the course of the movement showing a release from suppression at time points when feedback processing gains importance. We observed a similar modulation of the amplitude of the P45 component, an early somatosensory brain potentials originating in primary somatosensory cortex. Reduced P45 amplitudes were associated with stronger tactile suppression. Overall, our results speak for a dynamic adaptation of the somatosensory system to facilitate successful interactions with the environment.

Talk #5.4: The effect of otolith noise on vestibular perceptual latency and temporal binding windows

Perry Emily (1), Gallagher Maria (2)

1 - University of Kent (United Kingdom)
2 - University of Kent (United Kingdom)

Research into multisensory integration shows clear influences of sensory noise on perceptual estimates and precision. However, fewer studies consider the role of sensory noise on temporal aspects of multisensory integration, such as temporal binding windows. We investigated whether vestibular noise induced through a head-down full-body tilt of 25° would widen temporal binding windows in a visuo-vestibular integration task. Participants completed a temporal order judgement task, reporting whether they felt a head movement or saw a light first. Eight stimulus onset asynchronies (SoAs) from ±600- 0ms in 150ms steps were used, where negative SoAs were 'visual first' and positive SoAs were 'vestibular first', with synchronous presentation at 0ms. Vestibular stimulation involved a single 1.2 second cycle of sinusoidal binaural-bipolar galvanic vestibular stimulation

stimulus of 2.5 mA and a frequency of 0.83Hz which induced an illusory head movement first to the left and then to the right. Visual stimulation involved viewing a green LED light blink for 1 second. Participants completed the task both upright and tilted in a counterbalanced order. Preliminary analysis replicates previous findings indicating that vestibular signals are perceived more slowly than visual cues. Interestingly, tilting the body slows vestibular perception even further (~+100ms), and temporal binding windows are substantially wider in tilted vs upright conditions. These findings suggest that otolith noise induced with body tilt affects the perceptual latency of vestibular stimulation relative to visual stimulation, as well as widening temporal binding windows for visual and vestibular input. Therefore, sensory noise affects the temporal aspects of vestibular multisensory integration.

Talk #5.5: Modality-dependent delay adaptation in sensorimotor temporal reproduction

Chen Lingyue (1), Shi Zhuanghua (2), Van Dam Loes (1)

1 - Sensorimotor Control & Learning Group, Centre for Cognitive Science, Technische Universität Darmstadt (Germany)
2 - Department of Psychology, Ludwig-Maximilians-Universität München, Munich, Germany (Germany)

Precise timing depends on aligning motor actions with their sensory consequences across modalities. When visual and tactile feedback occur with slight delays relative to movement, the brain must adapt to preserve a stable temporal relationship between action and sensation. The present work examines delay adaptation in sensorimotor timing, focusing on how visual and tactile feedback are weighted in both unimodal and bimodal contexts using a reproduction-based adaptation–test paradigm. Across a series of experiments, participants reproduced target durations by pressing and holding a button while receiving visual, tactile, or visuotactile feedback. During the adaptation phase, participants adapted either to a fixed delay between action onset and sensory feedback onset, or to a synchronized action and sensory feedback pairing without delay. In subsequent test phases, the delay was varied to assess the extent of delay adaptation. The adaptation effect was first examined within single modalities and then extended to bimodal contexts, including conditions that induced temporal conflicts between sensory modalities. The results consistently indicate that delay adaptation is partial and modality dependent. A greater reliance on tactile than visual feedback was observed in temporal reproduction, with the timing of tactile feedback both leading to stronger adaptation effects and dominating the reproduction task when a visuotactile conflict was introduced. Together, these experiments introduce a reproduction-based adaptation-test paradigm for investigating weighted multisensory integration in sensorimotor timing. The findings suggest that tactile input plays a privileged role in calibrating action-based temporal judgments.

Talk #5.6: Do eye movements shape how we hear? Oculomotor control of auditory cortex and perception during active sensing

Leszczyński Marcin (1) (2), Bickel Stephan (3), Nentwich Maximilian (3), Russ Brian (4), Parra Lucas (5), Lakatos Peter (4), Mehta Ashesh (3), Schroeder Charles (2) (4)

1 - Université Jagellon de Cracovie (Poland)
2 - Columbia University Medical Center (United States)
3 - The Feinstein Institutes for Medical Research, Manhasset (United States)
4 - Nathan S. Kline Institute for Psychiatric Research (United States)
5 - City College of New York, CUNY (United States)

Humans and other primates explore the visual world through rapid eye movements (saccades) that sequentially sample visual scenes. In visual cortex, non-retinal signals linked to saccades modulate neuronal excitability, placing visual populations into a high- excitability state as each saccade ends. Yet perception unfolds in a multisensory environment, raising a fundamental question: do eye movements also influence how the brain processes sound? Using intracranial recordings in humans during natural viewing, we found that saccades systematically modulate neural excitability across multiple auditory cortical areas. Strikingly, this modulation follows a temporal pattern complementary to that observed in visual cortex (Leszczynski et al., 2023). Network analyses further reveal bidirectional functional interactions between auditory cortex and oculomotor control regions, including the frontal eye fields, suggesting that signals related to saccade generation dynamically shape auditory cortical activity. These findings indicate that eye movements may coordinate excitability across sensory systems, aligning auditory processing with the visual sampling cycle. Building on these neurophysiological results, I propose that eye movements act as global control signals organizing multisensory processing during active behavior. In the presentation, I will highlight three complementary lines of research on multisensory active sensing that combine human intracranial neurophysiology, virtual reality, psychophysics, and eye tracking. Together, these studies aim to reveal how saccades shape auditory neural activity, auditory perception, and cross-modal coordination during natural exploration, supporting the view that eye movements are a key mechanism organizing perception across the senses.

TALK SESSION 6

JUNE 26th | 9:00 am – 10:30 am
PONENTE ROOM

Multisensory processing and learning

Chair: Petra Vetter

Talk #6.1: Crossmodal temporal recalibration does not accumulate across sessions

Bruns Patrick (1), Felsenheimer Anne (2) (3), Röder Brigitte (1) (4), Abbasi Hossein (1)

1 - University of Hamburg (Germany)
2 - Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig (Germany)
3 - University College London (UCL) (United Kingdom)
4 - LV Prasad Eye Institute (India)

Exposure to a consistent audiovisual spatial or temporal discrepancy typically induces recalibration of auditory localization (spatial ventriloquism aftereffect) or of the point of subjective simultaneity (PSS) between auditory and visual events (temporal ventriloquism aftereffect), respectively. Although such recalibration has usually been considered transient, recent findings demonstrated that the spatial ventriloquism aftereffect can persist across sessions. Here we tested in two experiments (n = 46 each) whether crossmodal temporal recalibration shows similar stabilization. In preregistered Experiment 1, participants completed three sessions on separate days. Each session contained an audiovisual simultaneity judgment task before and after an adaptation phase with a fixed stimulus onset asynchrony (SOA) of either 0 ms or 230 ms visual-lead, depending on group. Within each session, PSS shifted from pretest to posttest according to the adapted SOA, demonstrating robust temporal recalibration. Across sessions, however, PSS values tended to move toward veridical simultaneity in both groups, reflecting unspecific test repetition effects rather than retention of SOA-specific recalibration. To test retention at shorter time scales, Experiment 2 included two sessions on the same day, separated by a break. Session 1 used either 0 ms or 230 ms SOA, whereas in Session 2 all participants adapted to 230 ms. Clear temporal ventriloquism aftereffects again emerged within each session, but no carry-over effects from Session 1 to Session 2 were observed in either pre- or post-adaptation PSS. Overall, these findings suggest that crossmodal temporal recalibration, in contrast to spatial recalibration, is a transient process that is rapidly overwritten by new crossmodal correspondences.

Talk #6.2

Talk #6.3: Modality-specific serial dependence effects for judgments on auditory and visual motion direction

Stoyanova Kalina (1), Tiesman Adam (2) (1), Bertisch Hannah (1), Ramachandran Ramnarayan (3) (2), Wallace Mark (2) (1)

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2 - Vanderbilt Brain Institute (United States)
3 - Vanderbilt University Medical Center, Nashville (United States)

From a Bayesian perspective, the perception of audiovisual (AV) motion involves combining current auditory and visual information with priors on the sensory information. One way prior history can influence perception is through serial dependence effects (SDEs), or biasing perception of the current trial towards or away from the previous trial. Here, we examined the role of SDEs in both unisensory (i.e., auditory alone, visual alone) and cued AV motion perception. SDEs were assessed by comparing psychometric sensitivity and bias in trials conditioned on prior trials having specific stimuli or response characteristics. Participants (n=48) performed motion direction discrimination tasks in unisensory and multisensory conditions, with cueing instructions to attend to one or both component modalities. Auditory conditions resulted in an attractive SDE (i.e. bias toward the prior trial) and visual conditions resulted in a repulsive effect (i.e., bias away from the prior trial). Audiovisual cued AV trials showed no effect. These SDEs were both stimulus and response driven for auditory conditions but were only response driven for visual conditions. Together, these data suggest auditory motion attractive SDEs arise from a sensory locus while visual motion repulsive SDEs arise from a decisional locus. Those results form the hypothetical framework for ongoing EEG data collection in a new cohort of participants (n=12), where event-related potentials are examined to investigate prior history and if they corroborate with behavioral findings of modality-specific SDEs. This work will inform future studies aimed at elucidating the behavioral and neural mechanisms of audiovisual motion perception, particularly in populations where Bayesian priors are altered (e.g., autism, schizophrenia). This research was supported by an unrestricted gift from Reality Labs Research, a division of Meta.

Talk #6.4: The Shepard Swing: tracking endogenous bistability beyond vision

Domenici Nicola (1), Oess Timo (1), Wünning Katharina (1), Ernst Marc (1)

1 - Applied Cognitive Psychology, Universität Ulm (Germany)

Bistable illusions have been predominantly investigated in the visual domain, where they provide powerful tools to study spontaneous perceptual alternations. However, auditory counterparts remain comparatively underexplored. Here, we introduce the Shepard Swing, a novel auditory bistable stimulus designed to elicit endogenous perceptual switches between rising and falling pitch. To validate our new stimulus, we presented participants with 120-second sequences of superimposed ascending and descending Shepard tones, perceptually ambiguous with respect to the direction of pitch-gradient. Perceived direction was continuously reported via a sustained key press. Crucially, all participants experienced multiple spontaneous reversals, with mean phase durations of 8.6 seconds and a positively skewed distribution of durations as expected with canonical visual bistable dynamics. Percepts of rising and falling pitch were balanced, and switching patterns were statistically independent across individuals, consistent with stochastic endogenous competition. Building on these results, we further examined how multisensory interactions modulate the temporal dynamics of this auditory switching. By introducing cross-modal signals temporally aligned with the bistable stimulus, we then tested whether endogenous perceptual competition in audition is susceptible to multisensory input, revealing systematic cross-modal effects on spontaneous auditory bistability. Overall, these findings establish the Shepard Swing as a reliable paradigm for investigating spontaneous perceptual alternations in audition and offer a platform for probing the multisensory and neural mechanisms underlying bistability across sensory modalities.

Talk #6.5: Multisensory timing meets evidence accumulation in MS

Bollini Alice (1) (2), Campus Claudio (2), Podda Jessica (1), Cuturi Luigi (3) (2), Bellosta Alice (1) (4), Pedullà Ludovico (1), Brichetto Giampaolo (1), Tacchino Andrea (1), Gori Monica (2)

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4 - Dipartimento di Neuroscienze, riabilitazione, oftalmologia, genetica e scienze materno-infantili, Genova (Italy)

Cognitive slowing is a significant source of disability in multiple sclerosis (MS), yet the perceptual mechanisms that may contribute to reduced processing speed remain poorly specified. Because everyday perception and action rely on integrating information across senses, reduced multisensory temporal precision could be an under-recognised bottleneck for efficient cognition. In a pilot study, we tested multisensory temporal order processing in 19 people with MS (PwMS) and 19 age- and sex-matched healthy controls using three psychophysical Temporal Order Judgment (TOJ) tasks: audiovisual (AV), audiotactile (AT), and visuotactile (TV). For each modality pair, we estimated the point of subjective simultaneity (PSS) and just noticeable difference (JND) from fitted psychometric functions, indexing temporal bias and temporal sensitivity, respectively. To move beyond summary accuracy and capture latent decision dynamics, we modelled trial- level choices and reaction times with Hierarchical Drift Diffusion Modelling (HDDM), estimating drift rate, boundary separation, non-decision time, and starting-point bias. PwMS showed significantly enlarged JNDs across AV, AT, and TV conditions, indicating a global reduction in multisensory temporal precision, while PSS values were preserved. Group-level HDDM parameters did not differ reliably, suggesting largely preserved decision architecture despite noisier sensory evidence. Within PwMS, better processing speed (Symbol Digit Modalities Test) was associated with lower boundary separation and reduced starting-point bias, consistent with less conservative, less biased decision- making in individuals with higher cognitive efficiency. These results support a perception–cognition link in MS: multisensory temporal imprecision may increase decisional demands

Talk #6.6: Testing candidate processes to explain individual differences in audiovisual integration using a novel cue

Chazelle Thomas (1), Wright Scarlett (1), Velimachitis Georgios (1), Hand Sophia (1), Fenwick Sam (1), Allen Chris (1), Scheller Meike (1), Nardini Marko (1)

1 - Department of Psychology, Durham University (United Kingdom)

The ability to learn to integrate sensory cues in novel ways, such as using pitch for multisensory localisation, varies greatly across individuals - yet the sources of this variability remain poorly understood. Novel cues tend to be integrated less than familiar cues, yet some participants still seem to benefit from them (Aston et al., 2022). Recent findings also suggest that multisensory integration benefits are individual-specific, but stable over time (Scheller et al., 2026). Across two experiments, we investigated multisensory integration benefits over time, across novel and familiar cue pairs, to identify factors underlying these individual differences. In Experiment 1 (N = 105 tested over two 2-hour sessions), participants performed an audiovisual localisation task using familiar cues (visual spread and sound source) and newly trained cues (colour and pitch), on their own or in audiovisual pairs. A computational modelling approach revealed large individual differences in learning and integration across different cue pairs. We will further use mixed effects models to test whether multisensory benefits could be predicted by participants' temporal binding window, working memory span, musical proficiency, and alertness levels. In Experiment 2 (N = 75, target N = 200), we examined whether pre- existing pitch-space cross-modal correspondences influenced the ability to use a novel pitch-to-location mapping. Preliminary results suggest that using an atypical mapping (e.g., low pitch = up) affects horizontal and vertical localisation differently, potentially explaining why some

participants struggle more to integrate novel cues. These findings inform which cognitive factors may drive interindividual variability in multisensory integration.

POSTER SESSIONS

POSTER SESSION 1

JUNE 25th | 10:30 am – 11:45 am

HALL

Body Representation, The Bodily Self & Spatial Boundaries

Poster #1.1: Learning to use a newly functional arm: a developmental perspective

Cowie Dorothy (1), Moffatt Jamie (1), Marco Gillies (2), Pan Xueni (2), Johannsen Leif (3), Thurlbeck Simon (1)

1 - Durham University (United Kingdom)
2 - Goldsmiths University of London (United Kingdom)
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The Go-Go technique is a Virtual Reality manipulation of the virtual arm, allowing the user to dynamically extend their virtual arm beyond the limits of their real arm. To make successful reaches with the Go-Go arm, the user must adapt their movements to the novel multisensory pairings of visual, proprioceptive and motor information. In a first experiment, we found that adults, but not younger children (5-7 years) or older children (8-10 years) felt reduced sense of ownership over a virtual arm extended to a maximum of 4x the length of their real arm. All ages adapted their reach kinematics well to the new arm, increasing reach velocity in Go-Go conditions while maintaining safely controlled reaches. In a second experiment, children (7-9 years) and adults made numerous reaches with the Go-Go arm in 3 sessions to examine how the novel visuo-motor control scheme is learned over time. Learning of the Go-Go arm will be indexed by the rate at which reach kinematics (e.g. peak velocity, movement time), resemble identical movements made without the arm extension. We expect children may adapt more quickly than adults. in addition, we expect prior exposure to Go-Go will facilitate quicker adaptation to a novel Go-Go arm. To assess Go-Go influence on body representation, behavioural tasks assessed how far participants felt they could reach, and perceived distance between touches to the real arm. We expect that greater Go-Go arm extensions will lead to a longer internalised body representation of the arm.

Poster #1.2: Multisensory integration and body ownership after peripheral nerve injury: a classical rubber hand illusion study

Lustenhouwer Renee (1)

1 - Utrecht University, Utrecht (Netherlands)

Neuralgic Amyotrophy (NA) is a relatively unknown, yet common peripheral nerve disorder. Auto-immune inflammation damages the nerve bundle innervating the upper extremity, causing acute pain and paresis in the affected limb. This muscle weakness often results in abnormal movement patterns.

Despite recovery of peripheral nerves, the majority of patients experience persistent motor dysfunction and subsequent residual complaints. Recent work relates persistent motor dysfunction to altered central mechanisms. Reduced activity in visuomotor brain regions may point towards altered multisensory integration and body ownership in the affected limb. Here we apply the classic Rubber Hand Illusion paradigm to test that hypothesis. We compare age- and gender-matched controls to two groups of patients with asymmetrical NA affecting their dominant side. One group of patients has completed specialized rehabilitation targeting central motor processes, whereas the other group is naïve to specialized treatment. Participants undergo the classic Rubber Hand Illusion with synchronous and asynchronous tactile stimulation on both their dominant and non-dominant hand. We measure proprioceptive drift, (dis)embodiment and physical sensations with an embodiment scale. We additionally measure handedness (Edinburgh Handedness Inventory), shoulder function (Shoulder Rating Questionnaire – Dutch Language Version) and pain (Visual Analogue Scale). Preliminary results show that both treated and untreated NA patients are able to experience the Rubber Hand Illusion, indicative of intact multisensory integration of visual, tactile, and proprioceptive information relating to their affected limb. No significant group differences have emerged, though data collection is ongoing and sufficient power is yet to be reached.

Poster #1.3: Researching body perception: toward an integration of quantitative and qualitative interdisciplinary approaches to address the multiplicity of bodily experiences

Roel Lesur Marte (1) (2), Srinivasan Karunya (1), Turmo Vidal Laia (3), Longo Matthew (4), Jenny Slatman (5), Väljamäe Aleksander (6), Tajadura-Jimenez Ana (1) (7)*

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2 - Department of Psychology, University of Zürich (Switzerland)
3 - KTH Royal Institute of Technology, Kista (Sweden)
4 - Department of Psychological Sciences, Birkbeck, University of London (United Kingdom)
5 - Department of Culture Studies, Tilburg School of Humanities and Digital Sciences (Netherlands)
6 - University of Tartu (Estonia)
7 - UCL Interaction Centre, University College London, London (United Kingdom)
**speaker*

Advances in multisensory research within experimental psychology and cognitive neuroscience have brought significant insights to the field of body perception. Standardized approaches typically employ multisensory manipulations alongside physiological, behavioural, subjective, and psychophysical measures to investigate one's body experience. However, these methods alone may sometimes fall short of capturing the full complexity of bodily experience, resulting in construct ambiguity, dissociations between measures, and a reduction in experiential nuance. In this work, we advocate for a mixed-methods research program that bridges quantitative experimental paradigms with qualitative design research practices centred on lived bodily experience. We argue that qualitative tools such as first-person descriptions, body maps, exploratory workshops, and iterative design engagements can meaningfully complement quantitative methods without compromising scientific rigor. Integrating these approaches enables researchers to better account for individual differences, increase transparency in the development of experimental paradigms, and foreground experiential dimensions that might be overlooked in purely quantitative studies. We outline a three-stage integration model aligned with key phases of scientific inquiry (experimental design, data collection, and integrative analysis) and provide a set of qualitative tools to support this process. We contend that this approach is essential for studying body perception. In contrast to other features of perception, one's body is both the subject and object of experience, not only perceived by oneself but also by others, and is therefore shaped by significant social and affective aspects. Overall, the proposed framework offers a

pragmatic pathway for multisensory researchers to expand methodological toolkits and deepen our understanding of body perception.

Poster #1.4: Growing bigger than the gap: investigating body-space interactions during a haptic illusion altering perceived body size

Srinivasan Karunya (1), Márquez Segura Elena (1), Martínez-Córtes Tomás (1), Soto-Faraco Salvador (2) (3), Tajadura-Jiménez Ana (1) (4)

1 - i_mBODY Lab, Universidad Carlos III de Madrid (Spain)
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4 - Interaction Centre, University College London (United Kingdom)

Perception of the environment is body-scaled: we perceive object-size, and act, relative to how large our body feels. Judgements about affordances (e.g. whether an aperture is passable) are therefore based on perceived rather than veridical body dimensions. Body representations can be experimentally altered through sensory illusions, providing a systematic way to test how changes in perceived body-size recalibrate perception of and interaction with environmental properties. We present VibrOut, a novel muscle-vibration–induced kinaesthetic illusion, which, when applied to a participant standing still with eyes closed, creates the sensation of the arms opening in the frontal plane, increasing perceived horizontal body extent. In an ongoing study, we evaluate whether this illusion alters both contextually relevant body-perception and action through two tasks: 1) active task, measuring shoulder-rotation when walking through apertures of different widths, 2) passive task, measuring subjective judgements of fitting in apertures of different widths. In both tasks, participants open their eyes to complete the task after 15s of vibration. Pilot data from the second task (N=8) indicate that participants judge their bodies need significantly wider apertures to fit during vibration-illusion compared to no-vibration. We hypothesise that beyond altering static body perception, the vibration-illusion will also shift action boundaries: participants rotating their shoulders to pass through wider apertures than in control conditions (no-vibration, vibration-control). This study will offer insights into haptic body-illusions in static and active contexts, and into how perceptual and action-oriented body representations shape our perception of and interaction with the environment.

Poster #1.5: Altered sensory selection may contribute to older adults' stronger visual bias in hand position perception

Teramoto Wataru (1), Sato Yoshiyuki (2), Kuroda Naoki (3) (4), Harada Shinya (1)

1 - Kumamoto University (Japan)
2 - Aichi Shukutoku University (Japan)
3 - Ritsumeikan University (Japan)
4 - Japan Society for the Promotion of Science (Japan)

Body position perception, which is essential for planning goal-directed actions, is established primarily through the integration of visual and proprioceptive information. Previous studies have shown that visual information tends to outweigh proprioceptive information with age. Recent studies using Bayesian causal inference (BCI) models, including our previous work, suggest that this stronger visual bias can be explained by two factors: reduced proprioceptive precision relative to visual precision and an increased common-cause prior. The present study aimed to examine the latter factor in more detail, specifically whether it reflects a distortion in the process of selecting sensory information for

integration. In the experiment, several levels of mismatch between visual and actual hand positions were introduced using a large tabletop display and position sensors. Participants performed a reaching task under upright and inverted visual-hand conditions. If the common-cause prior remained high even in the inverted condition, this would indicate an age-related decline in the ability to appropriately select sensory information for integration. BCI modeling of reaching errors showed that the common-cause prior remained high for approximately 30% of older adults even in the inverted hand condition, whereas it markedly decreased in the inverted relative to the upright condition in younger adults. These findings suggest that the increased common-cause prior observed in older adults may reflect a distortion in multisensory integration, whereby irrelevant sensory information is not appropriately excluded.

Poster #1.6: Upper limb perceptual and motor errors

Gay Ayla (1) (2), Risso Gaia (1) (3), Akselrod Michel (1) (4), Scaliti Eugenio (5), Crottini Francesco (6), Becchio Cristina (7), Serino Andrea (4), Bassolino Michela (1) (3)

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4 - MySpace Lab and NeuroRehab Research Center, Service of University Neurorehabilitation (SUN) (Switzerland)
5 - Università degli studi di Torino (Italy)
6 - University of Pavia (Italy)
7 - University Medical Center Hamburg-Eppendorf (Germany)

Even in healthy individuals, representations of our own body are not entirely accurate. People typically perceive their hands as shorter and wider than they actually are (Longo & Haggard, 2010; Peviani & Bottini, 2018). However, while shape and size distortions are well studied, less is known about how we perceive the spatial location of our body parts without visual guidance, and how such distortions influence motor execution. In this experiment, we investigated upper-limb representation in healthy right-handed adults (N=21) using a body landmarks localization task. Participants verbally indicated when a moving stick aligned with specific landmarks on their hidden right arm, in 4 different spatial positions forming a square. They consistently underestimated their arm length by ~20% across all spatial positions. Additionally, their estimated positions deviated by ~10 cm from the real positions, typically biased toward the midline and closer to the body, with increasing mislocalization across trials. In a subsequent pointing task using the same 4 positions, participants reached forward without visual feedback or online correction, overshooting targets by ~5 cm. Crucially, perceived (and not real) arm length significantly predict the pointing trajectory length, suggesting that participants used their internal distorted body dimensions rather than veridical ones. These findings broaden our understanding of upper-limb representation by showing how perceptual distortions shape motor behavior.

Poster #1.7: Investigating the role of multisensory integration in anomalous sensory experiences through novel sensory illusions

Jennison-Boyle Amy (1), Ropar Danielle (2), Maidment David (1), Newport Roger (1)

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2 - University of Nottingham (United Kingdom)

Anomalous perceptions, sometimes labelled paranormal, are reported around three times more by autistic people than the typically developing population. Differences in how autistic people bind

congruent multisensory inputs to construct meaningful events could lead to misinterpretation of sensory events. This study investigated multisensory integration (MSI) through illusions designed to alter perceptions of the wrist and arm. Integration of concurrent visuo-tactile inputs is thought to underpin most body illusions; therefore, illusion susceptibility might indicate more accurate visuo-tactile binding. This study aimed to investigate how illusion experience and autistic traits (ATs) relate to anomalous experiences (AEs). It was hypothesised that people less susceptible to the illusions, and with higher ATs, are more likely to inaccurately bind visuo-tactile inputs, leading to more day-to-day sensory-based AEs. Participants completed questionnaires to measure AEs and ATs, then experienced two illusions through a combination of seen and felt touches to both arms. Illusion experience was explored qualitatively and through quantitative ratings. Over 75% of participants reported illusory experiences, such as feeling their wrist and/or arm change shape. Analyses revealed people more susceptible to the illusions and people higher in ATs reported more types of AEs in their everyday lives. However, illusion susceptibility and ATs were not related. The relationship between illusion susceptibility and AEs suggests that some AEs may be related to sensory processing. Previous findings associating ATs and AEs are supported, but results indicate this may not be underpinned by MSI. The relationships between MSI, illusion susceptibility, ATs, and AEs appear complex and require further investigation.

Poster #1.8: Body ownership in somatic symptom disorder

*Van Der Boom Kees Jan (1) (2), Keizer Anouk (2), Van Grondel Julian (2), Geenen Rinie (2), Dijkerman H. Chris (1) (2)**

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**speaker*

Persistent physical symptoms are associated with multiple biological and psychosocial contributing mechanisms. A sparsely considered, but possibly relevant factor concerns body representation distortions. The aim of this study was to examine differences in the sense of body ownership in patients with somatic symptom disorder (SSD). Participants with SSD (n = 28) and matched healthy controls (n = 26) were subjected to the rubber hand illusion (RHI) (Botvinick & Cohen, 1998). The (visible) rubber hand and the (invisible) participant's real hand were stroked in a synchronous (illusion) and asynchronous (control) condition for 60 seconds. The experience of body ownership was assessed by an objective measure, proprioceptive drift (shifting of the felt location of the real hand towards the rubber hand) and a subjective measure, the Embodiment Scale. This measure contains three subscales, Embodiment (of rubber hand), Disembodiment (of real hand) and Physical Sensations (Romano et al., 2021). Preliminary analyses showed no significant difference between patients and controls on proprioceptive drift in either the synchronous or asynchronous condition. The two groups also did not differ in the embodiment of the rubber hand in either condition. They did however differ in disembodiment of the own hand in the synchronous condition, patients displaying a less negative score. Furthermore, the patient group showed a larger variance in experiencing physical sensations during both conditions. Overall results offer modest support for differences in the subjective aspects of body ownership in patients with persistent physical symptoms. In particular, patients experienced more disembodiment of the own hand in the illusion condition and reported a wider range of physical sensations during both illusion and control conditions.

Poster #1.9

Poster #1.10: Sensory conflict in virtual reality: the relationship between depersonalization, vection, and motion sickness

Berti Stefan (1) (2), Todisco Emilia (1) (2), Missaghi Sara (3) (2), Gupta Nivedita (4) (2), Keshavarz Behrang (2) (3)

1 - Johannes Gutenberg University (Germany)
2 - University Health Network, Toronto (Canada)
3 - Toronto Metropolitan University (Canada)
4 - Ashoka University (India)

Motion sickness in virtual reality (VR) is a prototypical example of multisensory conflict, with visual cues of self motion contradicting vestibular and proprioceptive inputs. To investigate how affective, self representational, and interoceptive factors modulate this conflict, we exposed participants to visual motion that generated either lateral or rotational vection, thereby creating a controlled visual vestibular mismatch. Forty eight participants (age range 20-49 years) completed the Simulator Sickness Questionnaire (SSQ) and questionnaires assessing depersonalisation (CDS), state-trait anxiety (STAI), interoceptive attention (IATS), and interoceptive accuracy (IAS). Exploratory correlations showed CDS positively associated with IAS (p 0.1). A multiple regression predicting the SSQ total score from visually induced motion sickness susceptibility (VIMSSQ), IATS, CDS, and STAI explained 62 % of the variance (adjusted R^2= 0.62). Significant positive predictors were VIMSSQ (β = 5.30, p < 0.001), CDS (β = 0.33, p = 0.045) and state anxiety (β = 2.09, p = 0.001); IATS contributed only marginally (β = 0.42, p = 0.07). These findings demonstrate that the severity of VR sickness is amplified by strong visual vestibular conflict together with heightened depersonalisation and anxiety, while pure interoceptive accuracy alone does not directly drive sickness. The CDS IAS correlation suggests that depersonalisation may moderate the integration of bodily signals during multisensory conflict, offering a potential target for adaptive VR mitigation strategies.

Poster #1.11: Age-related changes audiotactile peripersonal space between rear and front space

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3 - Kumamoto University (Japan)

Peripersonal space (PPS), which refers to the space immediately around the body, plays an important role in interacting with external objects and avoiding potential threats. Our previous work demonstrated that PPS extends in all directions around the body and that its spatial characteristics differ between the frontal and rear spaces (Teraoka et al., 2024). Previous studies have also reported that PPS is expanded in older adults relative to younger adults. However, because most aging studies have focused exclusively on PPS in front of the body, it remains unclear whether aging affects PPS uniformly across space or instead alters its front-rear spatial asymmetry. To address this issue, the present study examined age-related changes in the spatial characteristics of PPS in the frontal and rear spaces using approaching auditory stimuli.

Poster #1.12: Remapping peripersonal space through tool-based and movement training in virtual reality

Christodoula Gavriel (1), Petrizzo Irene (2), Najm Ali (3), Avraam Savvas (3), Avraamides Marios (3), Kyriaki Mikellidou (1)

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3 - Centre of Excellence CYENS (Cyprus)

Peripersonal space (PPS) refers to the multisensory representation of the space immediately surrounding the body and supports rapid defensive and goal-directed interactions. PPS is highly plastic and can expand following actions that bring objects closer to the body. However, it remains unclear whether PPS remapping depends specifically on goal-directed pulling actions or can also arise from general body movements. The present study investigated whether PPS expansion requires pulling objects toward the body or can be induced by torso or whole-body movement training in immersive virtual reality (VR). Thirty-four healthy adults (17 women) completed a fully within-subjects 3 × 2 design with Training Condition (Pulling Training, Torso Movement, Whole-Body Movement) and Time (Pre, Post). PPS was assessed using a visuo-tactile detection task in VR. Reaction times to tactile stimuli presented at five distances were fitted with sigmoidal functions, and the inflection point (x_0) indexed PPS boundaries. Bootstrap resampling (12,000 iterations) was used to estimate boundary distributions and assess statistical significance. Pulling training produced a significant expansion of PPS (Pre: 1.01 m; Post: 1.45 m; p = .021), whereas torso and whole-body movements showed non-significant changes. Model fits were robust across conditions (R^2 = .96–.99). These findings indicate that PPS remapping depends on goal-directed pulling actions that bring objects closer to the body, rather than movement alone. VR-based pulling training multisensory and applied contexts.

Poster #1.13: Neural markers of temporal and spatial processing in visuo-tactile integration: towards a peripersonal space-time field

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Peripersonal Space (PPS) refers to the space immediately surrounding the body that the brain encodes as behaviorally salient for thriving and survival. This system relies on a distributed network that integrates multisensory bodily signals with external sensory events as a function of their spatial proximity. Classic studies have shown that multisensory interactions are enhanced when stimuli occur near the body compared to far, supporting a space-based definition of PPS. However, efficient action requires predicting when contact is likely to occur, suggesting that temporal congruency may be as fundamental as spatial proximity in shaping PPS responses. We propose an extension of the traditional framework toward a Peripersonal Space-Time (PPST) field, in which the brain's response depends on the joint spatiotemporal congruency of multisensory events. In this view, PPS mechanisms prioritize conditions that maximize the probability of imminent interaction, integrating where and when signals converge. To test this hypothesis, we recorded EEG activity during a visuo-tactile task in which visual stimuli were presented at two distances, either unimodally or paired with tactile stimulation at nine

delays. Preliminary results indicate stronger responses in high-beta for near vs. far stimulation, both for visual and visuo-tactile stimulation, confirming the spatial determinants of PPS processing. Investigating spatiotemporal combinations for visuo-tactile stimulation, a frequency-specific sensitivity emerged: low-beta activity is more responsive to spatial congruency, whereas high-beta is more sensitive to temporal congruency. Together, these preliminary findings support a unified PPST framework in which spatial and temporal regularities are encoded within a common network, multiplexed across distinct frequencies.

Poster #1.14: Virtual bubbles, real insights: a novel approach to measuring peripersonal space

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Peripersonal space (PPS) is the multisensory near-body space supporting object interaction. We developed a novel VR "Bubble Pop" task to measure PPS, where participants popped virtual bubbles with their hands. The task included two static conditions (stationary bubbles within/outside PPS) and four dynamic conditions (bubbles approaching at varying speeds and trajectories—aimed toward the body/face or moving parallel within/outside arms' reach). This design dissociated spatial boundary effects from motion and trajectory modulation. Static trials replicated the classical PPS gradient across distance ($\beta = -0.04$, $p = .048$). Dynamic trials were organized by trajectory (aimed vs parallel), differing in post- entry response timing ($\beta = -0.289$, $p < .001$). Dynamic trials showed ~17% shorter reach durations (≈0.09 s faster; $\beta = -0.1896$, $p < .001$), indicating motion reorganizes perceptual timing and action execution. Participants also completed a classical LED–tactile PPS task (Noel et al., 2020), replicating the canonical distance × direction interaction ($\beta = 236.31$, $p < .001$). Participant-matched cross- paradigm analyses showed that LED looming spatial gradients aligned most strongly with Bubble static slope architecture ($R^2 = .386$, $p = .041$), explaining ~39% of variance across participants. Static Bubble slopes therefore represent the closest analogue to classical PPS gradients. Within the dynamic conditions, aimed- approach trajectories toward the body showed the strongest alignment with LED looming ($R^2 \approx .19$), whereas other dynamic trajectories showed weaker associations. These findings demonstrate that the Bubble task captures both spatial PPS boundaries and trajectory-dependent dynamics, providing a novel VR assay for probing the architecture of near-space processing.

Plasticity & Neural Mechanisms

Poster #1.15: Brain state matters: activating a parietal-motor circuit through a motor task during cortical paired associative stimulation enhances neuroplasticity and motor function in older adults

Mirabelli Francesco (1), Finkelstein Taylor (2), Kopald Levi (2), Brissenden James (3), Lee Taraz (3), Taylor Stephan (4), Polk Thad (3), Bisio Ambra (5), Vesia Michael (2)

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Conventional transcranial magnetic stimulation (TMS) methods often target a single brain site to modulate neural activity, failing to account for functional interactions between brain regions that control sensorimotor behavior. To address this, cortico-cortical paired associative stimulation (cPAS) can be used to induce Hebbian spike-timing-dependent plasticity and strengthen functional connections by precisely timing stimulation pulses between two brain regions. However, this circuit-based approach shows variable effects on brain and behavior, particularly in older adults. Some suggest that activating sensorimotor circuits during cPAS could modulate its efficacy, but this remains unexplored. Here, we examined how manipulating brain state with a motor task during cPAS of a parietal-motor grasping pathway influences neuroplasticity and motor function. Using a within-subject design, 13 older adults (mean age: 72 ± 5 years) underwent cPAS plasticity induction to the parietal-motor pathway either while performing a goal-directed force-tracking hand task or during a task-free resting state. A third condition stimulated a cortical region outside the grasping circuit during task performance. For each individual, we identified the optimal timing of functional interactions between the parietal and motor regions during the action-planning phase using a dual-site TMS grid-search method. We compared changes in motor cortical excitability and hand performance after each condition. We found that delivering individualized cPAS to the parietal-motor circuit during the task enhanced neuroplasticity and motor performance compared to the rest condition. We conclude that constraining brain state with a behavioral task during brain stimulation can optimize neuroplasticity induction in brain circuits regulating sensorimotor processes in older adults.

Poster #1.16: Temporal constraints on auditory facilitation of visual search: differences between natural and speech sounds

Misumi Kan (1), Yamamoto Kosuke (1), Watanabe Katsumi (1)

1 - Waseda University (Japan)

Auditory cues can facilitate visual search, but the extent of this facilitation may depend on both temporal alignment and sound category. In multisensory research, clarifying how different types of auditory information interact with vision over time is important for understanding the mechanisms of cross-modal integration. The present study examined whether the effect of auditory cues on visual search efficiency differs between natural sounds and speech sounds as a function of stimulus onset asynchrony (SOA). Participants performed a visual search task in which they identified a target among distractors following an auditory cue. The SOA between the auditory and visual stimuli was set at 250 ms (short) or 1000 ms (long). Search efficiency was indexed by the slope of the reaction time function across set sizes. For natural sounds, search efficiency was higher in the short-SOA condition than in the long-SOA condition. In contrast, for speech sounds, search efficiency showed little difference between SOA conditions. These findings suggest that the influence of auditory cues on visual search is shaped by both timing and sound type. Natural sounds may facilitate visual search through relatively rapid multisensory integration, whereas speech sounds may depend more on semantically mediated processing. Overall, the results highlight that temporal constraints are central to understanding how auditory information modulates visual attention in multisensory environments.

Poster #1.17

Poster #1.18: Measuring multisensory integration in fNIRS: a comparison of quantification criteria

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Functional near-infrared spectroscopy (fNIRS) is a promising tool for investigating multisensory integration (MSI), yet no consensus exists on how to quantify integration from haemodynamic signals. Criteria developed for EEG – most notably the superadditivity criterion (AT > A + T) – are routinely applied to fNIRS data without systematic evaluation of their validity for this signal type. We recorded fNIRS responses to auditory (A), tactile (T), and audiotactile (AT) stimulation in 15 participants and compared four quantification approaches. Approaches 1–3 each tested superadditivity on HbO amplitude, HRF beta weights, or residual betas after unimodal regression; we show these are conceptually equivalent, all reducing to AT > A+T. In our data, these approaches yielded frontocentral effects apparently driven by modality-specific selectivity: channels with strong responses to one unimodal condition showed attenuated responses to the other, reducing the A+T additive estimate. While this pattern may reflect genuine neural dynamics, it complicates interpretation as an MSI index. Approach 4 regressed the summed unimodal signal A+T from the bimodal AT response, then fitted a canonical HRF to the residual, testing whether any non-linear component has a plausible haemodynamic shape. This yielded consistent positive beta values across participants, localised over temporoparietal channels where both unimodal responses were positive and robust – suggesting multisensory convergence in regions with balanced unimodal representations. We propose Approach 4 as a principled criterion for MSI quantification in fNIRS and discuss its theoretical grounding relative to existing frameworks.

Poster #1.19: Attentional selection of location and modality in touch and pain: an ERP investigation of crossmodal and intermodal effects

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The effect of spatial attention on tactile and nociceptive stimuli has been well documented. However, most studies have assessed the effect of attention on either one or the other modality, leaving the influence of crossmodal and intermodal attention on pain and touch largely unexplored. To address this issue, we asked participants to complete an attention task in which both the task-relevant location (left vs. right hand) and the task-relevant modality (pain vs. touch) were simultaneously cued on a trial-by-trial basis. Participants were instructed to respond vocally to targets delivered at the cued location in the cued modality, while ignoring uncued targets and all non-target stimuli. Modulatory effects of spatial attention on ERPs elicited by non-targets impacted sensory specific (P100, N140) as well as longer latency (Nd) components in both modalities. Results showed that effects of spatial attention on the cued modality were similar across touch and pain, albeit stronger for touch. Similarly, crossmodal attention effects (i.e., spatial attention to the uncued modality) showed a comparable time-course across modalities but were generally more pronounced for touch. By contrast, modulatory effects of intermodal attention (i.e., selection of the cued modality) emerged relatively

late, with enhanced negativities observed for the cued than uncued modality beyond 200 ms. Notably, this effect was restricted to cued locations and was more pronounced for touch than for pain. Taken together, these results suggest the presence of largely overlapping mechanisms for attentional selectivity across touch and pain, operating first on space and only subsequently on modality.

Poster #1.20: The functional and white matter organization of human ventral occipito-temporal cortex develop independently of visual experience

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How are functionally specific cortical regions wired up in development, and what is the role of experience? Here we show that the functional and white matter organization of the ventral occipito-temporal cortex (VOTC) develops independently of visual experience. We combined five MRI datasets to compare functional responses and white-matter connections of the VOTC in congenitally blind and sighted individuals. We first show that regions responding to faces (mFus, pFus), places (CoS) or words (pOTS) in sighted people maintain their categorical preferences in congenitally blind people even if triggered by sounds or touch instead of vision. In addition, despite minor differences, these VOTC regions shared highly similar white-matter connections across groups; organized by category, cytoarchitecture and even eccentricity. Together, these findings reveal how idiosyncratic white matter connections of discrete VOTC regions are independent from visual experience, likely constraining the expression of the functionally-specific crossmodal plasticity observed in people born blind.

Poster #1.21: The impact of increased walking requirements on cognitive processing and anxiety in university students

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Daily life requires the simultaneous management of motor and cognitive processes, which compete for shared cognitive resources. Walking is a complex behavior relying on multisensory integration, making cognitive–motor dual tasks ideal to study interactions between movement and cognition. While prior research has examined how locomotion influences concurrent cognitive performance, few studies have investigated how specific walking conditions (eg. Slope) modulate cognition and underlying neural mechanisms in students. In this study, twenty university students walked on a treadmill under three conditions (uphill, downhill, and flat) while performing a Discriminative Response Task with four Go/NoGo stimuli requiring rapid responses and inhibition. Brain activity was recorded using EEG and analyzed using event-related potentials. Post-task questionnaires assessed perceived motor and cognitive effort as well as state anxiety. Behaviorally, slope didn't affect accuracy

but slightly slowed responses during downhill walking, indicating largely preserved performance. Neural data revealed modulation of early sensory-attentional processing: both uphill and downhill walking increased P1 amplitudes and decreased N1 amplitudes relative to flat walking, reflecting altered attentional allocation during inclined walking. Late cognitive processing, indexed by P3, showed no main effect, but the differential P3 (Go–NoGo) revealed reductions during uphill walking, consistent with flexible resource reallocation under increased motor demands. Subjective measures confirmed that uphill walking was perceived as most physically and cognitively effortful, and STAI scores were lower after uphill walking. Overall, walking slope subtly reshapes cognitive performance and neural processing during cognitive–motor dual tasks, highlighting the dynamic interplay between motor demands, sensory processing, and attentional control in youth.

Poster #1.22: Does reward-driven visual distraction reduce sound temporal sampling?

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Reward conditioning creates changes in neuronal plasticity with substantial cognitive consequences. Our goal is to evaluate the impact of conditioned distractors on processing continuous targets that are multisensorially connected across time during selective attention. This study investigates value-driven capture by visual conditioned cues in audiovisual (AV) scenes, using behavioral and electroencephalography (EEG) recordings. We test the hypothesis that capture shapes how cortical activity locks in to sound temporal patterns. Observers (N=31) listened to amplitude-modulated (AM) sound while discriminating two visual object streams flickering at two different rates, searching the one match with sound AM. Peripheral color cues were displayed as well, and we evaluated EEG phase-locking values as a result of color-reward associative learning. In presence of conditioned colors, performance fell as a result and so did phase-locking of the AV target rate, in frontocentral scalp activity. This loss of temporal coherence in participant responses predicted their behavioral reward-driven loss of sensitivity to the AV task. Inconsistent neural temporal tracking furthermore extended to unimodal auditory response estimates. The findings suggest that when reward-driven distraction shifts attention away from multimodal targets, cortical tracking fidelity is being withdrawn across the senses. The change is consistent with inter-modal competition, where incentive salience cues break down multisensory streams established and tracked in time by cortex.

Poster #1.23: Inducing Hebbian plasticity in the primary visual cortex through a novel paired associative stimulation protocol

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The present work assesses the efficacy of a visual paired associative stimulation (vPAS) protocol combining TMS over the primary visual cortex (V1) with visual stimulation. We conducted three within-subjects experiments: Study 1 explored the protocol's effectiveness and its timing-dependency with EEG; Study 2 and 3 investigated whether these modulations translate to behavioural measures and are hemispheric specific. In Studies 1 and 2, healthy participants underwent three vPAS sessions in which TMS over left V1 was time-locked with contrast-reversing checkerboards presented in the

right visual hemifield. vPAS protocols differed in the timings between paired stimulations: InterStimuls Interval, 75 (vPAS), 100 (vPAS), and 125 ms (vPAS). In Study 1 (N=25), we recorded 75 100 125 visual-evoked potentials (VEPs) from lateralized pattern-reversal checkerboards before and after vPAS, and VEP amplitude was analysed. In Study 2 (N=23), behavioural effects were assessed using a contrast-detection task, in which participants discriminated the orientation of lateralized Gabor patches at different contrast levels. Perceptual sensitivity was measured using d′ and response criterion. In Study 3, participants underwent two protocols: the vPAS as before and a right- 75 hemisphere vPAS version (TMS over right V1 paired with left-hemifield checkerboards). 75 Before and after vPAS, participants perform the same contrast-detection task as in Study 2. Overall, results showed that vPAS induces timing- and hemisphere-specific effects, with protocol-dependent modulation only for stimuli presented in the left (unconditioned) hemifield. Specifically, vPAS reduced N75 VEP amplitude and improved contrast 75 sensitivity for left-hemifield stimuli, whereas vPAS and vPAS had no consistent effects. 100 125

Poster #1.24: Domain-specific functional plasticity in the visual communicative system of deaf individuals

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Efficient interpersonal communication relies on the integration of facial and vocal signals to decode multidimensional communicative information, such as identity, emotion, and speech. How the absence of one sensory modality reshapes the remaining communicative system remains unclear. Here, we investigated this question by systematically comparing deaf (N=140, age range facial identity, emotional expression, speech, and global motion processing in a series of unisensory and audiovisual psychophysical tasks. The results indicate that, across communicative domains, auditory deprivation does not lead to uniform enhancement or impairment of visual processing. Instead, deaf individuals exhibit preserved sensitivity for facial identity, static expressions, and visual speech, alongside selective reductions in sensitivity to dynamic emotional expressions and global motion. These selective reductions were predicted by individual differences in fluid intelligence, suggesting that cross-modal plasticity is constrained by domain-general cognitive resources. Together, these findings support a domain-specific account of functional plasticity, in which sensory loss reshapes the communicative system in a selective and cognitively mediated manner, rather than through uniform compensation or degradation.

Poster #1.25: Modulating visuomotor integration processes through action observation and non-invasive brain stimulation: evidence from the healthy and stroke population

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Hebbian associative plasticity is thought to underlie the formation of links between sensory and motor representations of movements and to contribute to motor resonance, i.e., the activation of the human

motor system upon seeing other people's actions, mediated by the action observation network. Our research group developed a visuomotor paired associative stimulation (PAS) protocol to experimentally modulate motor resonance responses via Hebbian associative plasticity. This cross-modal protocol repeatedly pairs transcranial magnetic stimulation (TMS) pulses over the primary motor cortex (M1) with visual stimuli depicting simple actions, such as a finger movement or grasping a bottle. In healthy individuals, pooled data from 80 participants showed that motor resonance features can be transiently rewritten after visuomotor PAS: the emergence of novel motor resonance responses occurred at the cost of the typical phenomenon. Importantly, the extent of this functional reorganization is predicted by changes in corticospinal excitability that happen already during PAS administration. In a proof-of-principle study on stroke patients with upper limb hemiparesis, we demonstrated the effectiveness of the visuomotor PAS targeting the impaired motor system in modulating ipsilesional M1 reactivity, with a muscle-specific enhancement of corticospinal excitability that depends on the kinematic features of the PAS-conditioned action. These findings indicate that visuomotor associative plasticity driven by action observation plays a critical role in shaping motor resonance and influences M1 excitability. Accordingly, non-invasive brain stimulation protocols targeting cross-modal associative plasticity could represent powerful tools for causally probing and modulating visuomotor properties of the human brain, both in healthy and damaged brains.

Poster #1.26: Mapping the plastic brain: how is audiovisual integration spatially tuned around the peripersonal space?

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Multisensory integration is constrained by spatial and temporal factors, yet these dimensions are often studied independently. In natural interactions, multisensory events unfold within an action-centered spatial framework. Peripersonal space (PPS) integrates sensory signals relevant for action and can be dynamically modulated by motor experience. We therefore asked whether audiovisual temporal integration is spatially tuned relative to PPS. In Experiment1, we measured the Temporal Binding Window (TBW) across egocentric distances using a Virtual Reality setup. Twenty-six participants performed an audiovisual simultaneity judgment task with stimuli presented at six distances (60, 90, 140, 180, 220, and 300 cm). Behavioural responses were analysed using a generalized linear mixed-effects model. Results revealed a significant effect of distance on TBW ($p = 0.0059$), with a minimum around 90 cm. Post-hoc comparisons showed a reduction in TBW between 60 and 90 cm ($\Delta = 63$ ms, $p = 0.0252$), followed by an increase between 90 and 140 cm ($\Delta = 75$ ms, $p = 0.136$). This pattern suggests that multisensory temporal integration may be optimized near the boundary of PPS. Because PPS can expand following tool-use training, Experiment2 tested whether modifying reaching space would affect this spatial tuning. In this ongoing study, nine participants performed the same task before and after a tool-use training in which they used a grasping tool to retrieve objects beyond their natural reaching distance. Preliminary results indicate a possible outward shift of the TBW minimum toward farther distances (around 140 cm) following training, although this effect is not yet statistically significant.

Speech, Language & Multisensory Communication

Poster #1.27: Does multisensory word generation reduce persistence errors?

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The generation effect (GE) refers to the memory phenomenon where self-generated information is better remembered than passively learned information. Multisensory learning is associated with improved recall, but it is still unknown whether it offers a greater advantage for self-generated information when compared to unisensory learning. The present study examined whether sensory modality (audiovisual, visual, and audio), influenced the likelihood of repeated incorrectly generated responses during a word-pair learning task. More specifically, we tested whether audiovisual trials were less likely than visual-only or auditory-only trials to produce the same incorrectly generated responses across attempts. A one-way ANOVA was used to compare persistence of incorrectly generated responses across the three modality conditions. Participants (N = 56) learned 20- word pairs per condition (from Nelson's association norms), each followed by a distractor task, and a cued recall test. The results showed that audiovisual trials were not less likely to yield repeated incorrectly generated responses compared to visual-only and auditory- only trials, F (2,110) = .764, p = .468. Numerically, audiovisual trials had worse incorrectly generated responses, followed by audio-only trials and lastly visual-only trials. These findings suggest that multisensory input does not substantially alter the recurrence of generation errors. This work contributes to a more nuanced understanding of how modality shapes memory performance and has implications for educational and occupational settings where reducing repeated errors is important.

Poster #1.28: Increasing concurrent multimodality for letter-sound association learning

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Multimodal learning approaches are widely hypothesized to enhance learning. However, empirical evidence is often limited to dyadic combinations of modalities rather than richer multimodal protocols. Importantly, real-life learning is often complex, such as in literacy acquisition, where learners must integrate visual, auditory, and motor representations of writing and speaking. Further, it is unclear whether it would be beneficial for literacy learning to engage those systems close in time, as, it could improve the mapping of letter representations between systems while increasing cognitive loads potentially being deleterious for learning. In the present study, we systematically tested whether progressively enriching the number of sensori-motor modalities close in time, i.e., within training trials enhances the learning of novel associations between spoken syllables and pseudoletters. Sixty-six adult participants underwent training under three conditions: bimodal (audio- visual), trimodal (audio-visual-writing), and quadrimodal (audio-visual-writing-speaking). Learning outcomes were evaluated using letter-sound association, visual perception of letters, writing letters and letter naming tasks. Results revealed that performance decreased as the number of engaged modalities increased during training: the bimodal condition consistently yielded superior acquisition relative to both trimodal and quadrimodal conditions. This pattern suggests that concurrently introducing

training modality beyond two load theory's prediction. At least in a learning context where several modalities are introduced in a restricted timeframe, our findings challenge the simplistic view that "the more, the better". They highlight critical constraints that should be delineated in future research, with implications for educational practices.

Poster #1.29: The more the merrier? Investigating the effects of multisensory encoding and feedback on the size of the generation effect

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The generation effect (GE) refers to improved memory for self-generated information compared to information learned passively. Multisensory learning has been associated with improved recall, but whether generated information is disproportionately advantaged by multisensory learning has not been examined. We assessed whether multisensory learning exhibits different effects for learning by generation (typing, speaking, both) versus passive learning (reading, listening, both). The role of feedback was also assessed. A 2 (Encoding: passively learn, generate) X 2 (Feedback: no, yes) X 3 (Sensory modality: auditory, visual, audiovisual) repeated-measures design was used, with feedback measured between participants. Participants (N = 141) learned 20 word pairs per condition (from Nelson's association norms), each followed by a distractor and cued recall test. The ANOVA yielded a significant GE (η 2 =.42, p < .001), but p sensory modality was not significant (p = .375). Thus, method of encoding was a better predictor of recall than the number or type of sensory modalities engaged during learning. The effect of feedback was significant (η 2 =.03, p = .028), and interacted with encoding (p p = .027) but its interaction with sensory modality did not reach significance (p = .055). Feedback had no effect on passive learning (M = .02, p = .999), but a significant effect diff on generation (M = 0.08, p = .005). The three-way interaction with sensory modality was diff non-significant (p = .608). This indicates that the effect of feedback varies across encoding conditions but not across sensory modalities. These findings contribute to the mixed literature on multisensory learning.

Poster #1.30: Tactile cues shape neural processing of speech in noise

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Language processing is inherently multimodal, and the exploitation of diverse sensory information becomes fundamental especially in adverse listening conditions. Despite the beneficial role of visual cues is well established, little is known about other sensory modalities, such as haptic modality (Guilleminot et al., 2022; Răutu et al., 2023, Răutu et al., 2025). This study examined whether temporally structured haptic cues can support speech-in-noise processing by modulating neural tracking of continuous speech. Electroencephalography was recorded from 30 right-handed, normal-hearing participants while listening to narratives presented as audio-only (A) - speech in traffic or multi-talker noise, or as audio-tactile (AT) - speech in multi-talker noise paired with vibrotactile stimulation at phoneme or word onsets. Speech comprehension and intelligibility were assessed, and neural synchronization with the speech envelope and tactile input was analyzed using univariate and multivariate Temporal Response Functions (mTRFs). Although behavioral results did not differ

significantly across conditions, neural tracking of the speech envelope showed earlier latencies in traffic than in multi-talker noise ($p<0.05$, cluster corrected). Importantly, vibrotactile stimulation significantly modulated neural tracking of target linguistic features (i.e. phoneme or word onsets; $p<0.05$, cluster corrected), although it did not enhance envelope tracking directly. Overall, the findings confirm the interfering impact of multi-talker noise (Straetmans et al., 2024) and suggest that haptic cues aligned with salient linguistic features shape cortical dynamics during speech processing in challenging listening environments.

Poster #1.31: Shared principles in brains and models of speech processing

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Speech comprehension relies on an active interplay between bottom-up tracking of acoustic structure and top-down mechanisms that select, enrich, and predict relevant information. Across a set of EEG studies, we investigated how listeners transform speech acoustics into higher-level features, focusing on (i) articulatory reconstruction from sound and (ii) computational principles potentially shared by brains and self-supervised models. We combined continuous speech listening with synchronized articulatory kinematics of the talker's vocal tract (electromagnetic articulography), extracting low-dimensional coordinative patterns via principal component analysis. To dissociate neural contributions of acoustics and inferred motor patterns, we used partial information decomposition to quantify unique, redundant, and synergistic encoding of acoustic and articulatory features in brain activity. Results show that listeners' neural signals encode articulatory-specific information that is not captured by the acoustic envelope alone, consistent with engagement of learned audio–motor mappings during perception. Importantly, reliance on articulatory reconstruction is dynamic: it increases when processing is more demanding and is modulated by listener experience, including second-language proficiency, suggesting adaptive recruitment of motor-based predictions depending on task and competence. In parallel, we tested whether self-supervised contrastive learning provides a normative account of these transformations. Representations from joint-embedding architectures captured behaviorally relevant variance and emphasized causal/predictive information, aligning with neural encoding strategies that are not purely driven by signal energy. Together, these findings support a predictive and flexible account of speech perception and illustrate how articulography, EEG, information theory, and representation learning can be combined to uncover principles of sensory information selection.

Poster #1.32: Critical periods cannot wait: visually driven phonetic encoding in the absence of hearing

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The first year of life represents a critical period for the acquisition of native phonetic categories. Whether this period is triggered by auditory input remains unclear. To address this question, we recorded EEG responses to continuous auditory and audiovisual speech in 38 children whose hearing was restored through cochlear implants (CIs) and in 37 age- matched hearing controls (HC). Half of the CI participants were congenitally deaf and experienced auditory deprivation throughout the first year of life, while the others acquired deafness (AD) later in development and were therefore exposed to speech during the typical window for native phonetic attunement. Using multivariate temporal response function modelling, we predicted neural activity from hierarchical acoustic-to-phonetic speech features, including sound envelope, phoneme onsets, and phonetic features. To examine the role of early sensory experience, phonetic features were chosen to be auditorily distinct but visually indistinguishable (e.g.,/b/vs./p/) or visually discriminable (e.g.,/m/vs./n/). Encoding of each additional feature was quantified as the EEG predictive gain obtained by stepwise addition of each predictor to the model. The phoneme onset gain was measured across all groups and conditions. By contrast, the gains for phonetic features depended on the sensory input available during the first year of life. During audio-only speech, auditory phonetic features enhanced neural speech processing only in HC and AD groups, whereas all groups benefited from visual phonetic features during audiovisual speech. Results indicate that the critical period for phonetic attunement is guided by a modality-flexible biological predisposition for speech signals rather than by auditory input.

Poster #1.33: Divergent paths in audiovisual speech integration: comparing the McGurk illusion in humans and the AV-HuBERT model

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The McGurk effect is a classical paradigm for examining audiovisual speech integration. As artificial intelligence (AI) advances toward human-level speech recognition, this illusion offers a benchmark for evaluating audiovisual speech perception in AI models. In this study, we tested the McGurk illusion using both congruent audiovisual speech stimuli and incongruent McGurk stimuli (i.e., facial articulation of /ga/ dubbed with the sound /ba/) from forty-five speakers, presented to forty-five human participants and to the audiovisual speech model AV-HuBERT. In human participants, we replicated the robust "da" illusion reported in our previous work (Dong et al., 2025, Psychonomic Bulletin & Review). In contrast, AV-HuBERT exhibited a different response profile. While humans predominantly perceived "da," the AI model most frequently categorized stimuli as "others" (61.0% ± 38.3%). The model's "da" responses (21.2 ± 31.6%) were comparable to its "ba" responses (10.0 ± 24.2%) and significantly higher than its "ga" responses (7.8% ± 23.1%). Notably, similar to human perceivers, the model's susceptibility to both the "da" and "others" category varied widely across speakers, ranging from 0% to 100%. These findings suggest that although current audiovisual models capture some speaker-dependent variability, their mechanisms underlying cross-modal speech perception diverge substantially from human biological processing.

Poster #1.34: Neural encoding of acoustic parameters underlying shape iconicity

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In spoken language, words whose sounds signify their meaning are referred to as iconic. Since studying iconicity in real words is confounded by prior semantic knowledge, iconicity is often investigated using pseudowords. Using a set of bisyllabic pseudowords comprising a consonant-vowel pair for each syllable, we showed that pseudowords can be consistently rated for meaning across multiple domains (e.g. the rounded-to-pointed dimension of shape). Further, the ratings map systematically to domain-specific sets of both whole-item and segmental (phoneme-level) acoustic features. In two separate functional magnetic resonance imaging (fMRI) studies, we assessed the encoding of acoustic parameters relevant to shape ratings of pseudowords. Participants rated auditory pseudowords along a rounded-to-pointed dimension while in the MRI scanner. Representational dissimilarity matrices (RDMs) of the ratings and of each acoustic parameter were compared with RDMs of the BOLD signal using spherical searchlights centered iteratively on each cerebral cortical voxel (representational similarity analyses, RSA). Not surprisingly, the RDMs of the ratings and of multiple acoustic parameters correlated with BOLD RDMs in auditory cortex. The RDMs of the acoustic parameters also correlated with BOLD RDMs in a number of frontal and parietal cortical areas, including the postcentral gyrus (primary somatosensory cortex) and precuneus (implicated in visual imagery). These findings suggest involvement of multiple neural processes associated with iconicity, including auditory and crossmodal processing.

Poster #1.35

Poster #1.36: Impact of multisensory simultaneity-judgement training on speech-in-noise perception in autistic children and adolescents

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Multisensory perceptual training narrows the temporal binding window (TBW) in typically develop- ing adults, thereby enhancing simultaneity perception and facilitating speech comprehension. Autistic children and adolescents demonstrate enlarged TBWs, alterations in audiovisual integra- tion, and speech perception. In the present study, multisensory training was conducted in autistic youth aiming to decrease TBWs, enhance simple, audiovisual integration and speech comprehen- sion in noise. The participants (n = 19, aged 8-17) underwent a brief multisensory training consist- ing of a modified Simultaneity Judgment Task (SJT) with feedback. Simultaneity perception of simple, audiovisual stimuli and perception of complex, speech stimuli were examined pre- training, immediately post-training, seven and 14 days post-training. Enhanced simple, audiovisu- al integration was demonstrated immediately after training ($p < 0.01$) and after seven days ($p < 0.05$) compared to baseline. No significant enhancement in word recognition was demonstrated post-training ($p = 0.16$).

The results suggest that a brief, multisensory training is suitable to en- hance simultaneity perception in autistic youth with the effects lasting for at least seven days. Future studies must examine possible moderating variables to determine how training paradigms should be designed to improve speech comprehension, and tailor interventions to specific sub- groups to increase their effectiveness.

Poster #1.37: How the human brain decodes semantic information from multiple modalities

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Language is inherently multimodal, requiring the brain to decode semantic information from signals as diverse as speech, text, and facial articulation. How these signals are integrated into a unified representation remains a central question in cognitive neuroscience. We addressed this using a densely sampled fMRI experiment (12 hours of BOLD imaging per participant, N = 6) while participants viewed naturalistic stimuli across three modalities: speech, text, and facial articulation. Using voxel-wise encoding models, we identified a shared brain network, including the superior temporal gyrus/sulcus (STG/STS), middle temporal gyrus (MTG), and inferior frontal gyrus (IFG), that represents semantic information in a modality-independent manner. At the same time, we observed modality-specific encoding: speech was represented in the bilateral planum temporale and inferior premotor areas; text in the bilateral lateral occipital regions, fusiform gyrus, and superior parietal cortices; and facial articulation in the right-lateralized occipital, fusiform, and superior parietal regions. Notably, semantic encoding performance was highest for text, followed by speech and facial articulation. Together, these findings reveal a hierarchical cortical architecture that supports the transition from sensory-specific processing to abstract, modality-independent language concepts.

Poster #1.38: Voice age modulates the prior probability of a common cause in audiovisual speech

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In multisensory perception, whether sensory inputs are integrated or processed separately depends on the brain's inference about their causal origin. Stimulus familiarity facilitates audiovisual integration in speech perception; however, it remains unclear whether such effects arise from changes in sensory precision or experience-dependent modulation of the prior probability of a common cause (). We addressed this question using the Causal Inference of Multisensory Speech (CIMS) framework in adult participants, manipulating familiarity via speaker age (adult vs. child voices) based on the own-age bias. Sensory noise parameters (and) were independently estimated from unimodal conditions, enabling selective evaluation of . Results revealed that was significantly higher for adult compared to child voices, whereas sensory noise parameters showed no robust modulation. Identity consistency between face and voice did not systematically influence integration parameters. These findings indicate that accumulated perceptual experience with age-matched voices primarily reshapes causal inference at the level of integration priors rather than early sensory encoding. The results underscore

a computational distinction between experience-driven causal expectations and identity-based congruency in audiovisual speech perception. Figure 1 Summary of the results of estimated parameters. Note. (a): indicates the mean auditory () and visual () noise for each stimulus condition; (b): indicates the mean values of integrated perceptual representation () for each stimulus condition; (c): indicates causal inference estimates (); and (d): indicates illusion rates (rates of the McGurk effects). Error bars represent standard errors of the mean. In this figure, adult stimuli are treated as familiar and child stimuli as unfamiliar, based on the own-age bias in adult participants. Accordingly, familiar face/voice corresponds to adult face/voice, whereas unfamiliar face/voice corresponds to child face/voice in the figure axes.

Poster #1.39: Is pupil response to speech and music in toddlers with cochlear implants asymmetric?

Fantoni Marta (1), Saksida Amanda (1), Ghiselli Sara (2), Orzan Eva (1)

1 - IRCCS Materno Infantile "Burlo Garofolo" (Italy)
2 - Azienda Usl di Piacenza (Italy)

Ear advantage (EA) reflects hemispheric asymmetries in auditory processing, typically manifesting as a right-ear advantage (REA) for speech and a left-ear advantage (LEA) for music in normally hearing individuals. Whether similar patterns are present in young children with cochlear implants (CIs) remains unclear. This study examined whether pupillometry, an objective measure of listening effort, could reveal asymmetric auditory processing in toddlers with bilateral CIs during monaural listening to speech and music. Thirteen toddlers with congenital hearing loss (mean age = 36.2 months) and early bilateral CIs participated. Pupillary responses were recorded while children passively listened to speech and music stimuli presented in quiet or with background noise. Each child completed two sessions: one with only the left CI active and one with only the right CI active. Pupil size data were analyzed using linear mixed-effects models. Results revealed a significant interaction between listening ear and stimulus type ($p = 0.047$). Speech elicited larger pupil dilation when processed through the left CI, indicating greater listening effort relative to the right CI and consistent with a right-ear advantage for speech processing. In contrast, music stimuli did not produce significant lateralized effects. Additionally, age and speech therapy frequency influenced pupil responses during speech and music trials, respectively. These findings suggest that early bilateral CI users pupillometry. Overall, the study demonstrates that pupillometry is a feasible, non-invasive method for assessing auditory processing and listening effort in very young children with cochlear implants.

Poster #1.40: Temporally correlated visual speech cues provide sufficient information for speech comprehension during a cocktail party and vocoded speech listening

Reynoso Jose (1), Nidiffer Aaron (1), Lalor Edmund (1)

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Audiovisual speech integration has been proposed to operate via two processing modes: a correlated mode – whereby temporally correlated visual speech cues enhance auditory cortical sensitivity; and a complementary mode – whereby complementary visual articulatory information enhances the categorization of auditory speech into linguistic units (Campbell, 2008). Here, we investigate under which listening conditions these modes aid in audiovisual integration. We hypothesize that a temporally correlated visual cue should aid in attending to a target speaker in a cocktail party scenario, but only minimally aid in comprehending degraded speech, where correlated information may be

redundant. Subjects (n = 21) perform a word detection task as they are presented with either degraded speech or a cocktail party paradigm in three conditions: audio only (A), audio and video of the speaker with an overlayed ellipse tracking mouth movements (audiovisual ellipse, AV), or audio and a clear video of the speaker (audiovisual full-face, E AV). The ellipse serves to mask most articulatory cues from the mouth while retaining FF the temporal information of the speech. As expected, preliminary data shows that presenting a speaker's full-face aids both speaker detection in a cocktail party scenario ($p < 0.01$) and comprehension of degraded speech ($p < 0.01$). Surprisingly, a temporally correlated ellipse also aids in both listening scenarios (all p's < 0.01). Further work using EEG will explore the neural correlates of these behavioral results. Using decoding models, we aim to investigate audiovisual speech integration in the correlated mode, and whether this integration differs based on listening condition.

POSTER SESSION 2

JUNE 25th | 3:45 pm – 5:00 pm

HALL

Sensorimotor Integration & Self-Generated Action

Poster #2.1: Alpha oscillations reveal multisensory rebalancing during self-touch

Italia Barbara (1), Zampese Carlotta (1), Tavazzi Carlo (1), Rossi Sebastiano Alice (1), Fossataro Carlotta (1), Garbarini Francesca (1) (2), Bruno Valentina (1)

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Traditionally used across different cultures, self-touch is an instinctual gesture assumed to enhance attention to internal states. It emerges early in development and persists into adulthood, manifesting spontaneously during emotional regulation. We previously demonstrated that self-touch alters the balance between sensory streams, enhancing interoceptive accuracy while suppressing exteroceptive perception, suggesting an attentional decoupling from the environment. Here, we aim to identify electrophysiological correlates of this cross-modal competition, testing whether self-touch modulates alpha- band power, a neural marker of sensory gating and self-referential processing. Participants underwent 5-minute resting-state-EEG recordings before and after two 10- minute postural manipulations where right hand touched either the left hand (self-touch) or an object (object-touch). Data were analysed using a data-driven non-parametric clustering approach comparing, for each condition, pre- vs. post-manipulation. Results show that self-touch modulates alpha-band power. Specifically, alpha power increased significantly from pre- to post-manipulation only in self-touch condition in a large bilateral fronto-centro-parietal cluster (p=0.018). Conversely, no significant changes were observed in object-touch condition. Our study provides electrophysiological support for a reconfiguration of multisensory hierarchies during self-touch. The alpha-band modulation reflects a selective gating mechanism, where internal bodily states become the primary focus of neural processing while competing external inputs are down-weighted. Consistent with alpha oscillation's role in cross-modal inhibition, self-touch promotes a transition from an exteroceptive focus toward an integrated interoceptive state. This sensory recalibration not only clarifies why we instinctively seek self-touch for affective regulation, but also underscores its importance for clinical conditions where the multisensory bond with one's own body has been compromised.

Poster #2.2: Amplified visuo-motor mismatch biases visual motion decisions

Hine Kyoko (1), Morimoto Hikaru (1), Nakauchi Shigeki (1)

1 - Toyohashi University of Technology (Japan)

We perceive our environment and take action to deal with it. Conversely, our actions also influence perception, particularly perceptual decision-making. Previous research has shown that when participants report the direction of visual motion through leftward or rightward body movements under different levels of physical resistance, their responses are biased toward the less resistance option. However, it remains unclear whether such biases are driven by actual physical resistance or by

perceived resistance arising from altered visuo-motor feedback. Across two experiments (Experiment 1: N = 17; Experiment 2: N = 16), participants performed a within-subject motion-direction discrimination task while wearing a head- mounted display. They reported motion direction by making leftward or rightward head movements. Importantly, physical head rotation was identical across directions; only visual feedback was manipulated. We altered visuo-motor gain between visual and physical rotation to modulate perceived resistance without changing actual movement demands. In Experiment 1, visual rotation was amplified relative to physical rotation on one side (lower perceived resistance), whereas gain was matched to physical rotation on the other side. In Experiment 2, visual rotation was attenuated on one side (higher perceived resistance). Generalized linear mixed-effects models revealed that visuo-motor gain significantly predicted participants' responses in Experiment 1 (Estimate = 0.230, z = 2.07), with responses biased toward the amplified-gain side. In Experiment 2, the gain did not predict responses (Estimate = 0.012, z = 0.11). These findings suggest that perceptual decision- making is selectively biased toward actions associated with lower perceived resistance, even when actual physical resistance remains constant.

Poster #2.3: Expected sensory outcome is embedded in action kinetics

*Agiv Alexandra (1), Mukamel Roy (1)**

1 - School of Psychological Sciences, Tel Aviv University (Israel)
**speaker*

In the current set of studies, we characterized whether and how action kinetics of voluntary actions are shaped by expected sensory outcome. Healthy adult participants (N = 40) were instructed to press a button equipped with a force-sensitive plate using their right-hand index finger. On some conditions the button triggered a sound and on other conditions it did not (participants knew the contingency in advance). We found that participants applied more force when the button did not trigger a sound vs. when the button did. Interestingly, when participants performed double taps, we found a similar force relationship in the first tap although the first tap was always silent and only the second tap triggered (or not) sound outcome. In other words, the association of the second tap with a sound affected action kinetics of the first tap. We also examined double-tap sequences across hands (i.e. right-to-left hand or left- to-right hand sequence). In this case we found an asymmetric pattern. In the left-to- right hand tap sequence, left hand force profiles were modulated by the association of sound to the right-hand tap. However, in right-to-left sequences no such modulations were found in the right hand, and participants applied similar force levels irrespective if the left hand generated a sound or not. Taken together, our results demonstrate that prediction of future action-outcome shapes action kinetics already in early stages of movement. The asymmetry in bimanual taps suggests that such sensory predictions might be preferentially stored in the right hemisphere.

Poster #2.4: Transfer of motor/tactile adaptation patterns from tone-generation to action-tone synchronization

Horváth János (1)

1 - Károli Gáspár University of the Reformed Church in Hungary (Hungary)

Psychological theories of human action posit that actions are represented in terms of their sensory consequences. In a recent study we found that motor adaptation to an auditory action-effect was similar to that observed when participants performed a sensorimotor synchronization task, suggesting that synchronous action-tone events may be encoded as action-effect events. To test this hypothesis,

the present experiment (N=104) investigated whether motor (tactile) adaptation patterns to an action-effect contingency in a finger tapping task would be transferred to adaptation patterns in a subsequent sensorimotor synchronization task. Taps typically comprise two tactile transients: the initial impact transient is followed by a slow force development peaking 50-200 ms later. Participants may rely on both tactile features in their sensorimotor synchronization performance. To introduce a between-group bias in the representation of the action-effect relationship, in the first phase of the experiment the tone action-effect was triggered by the initial transient in one group, and by the slow peak in the other group. The manipulation was successful: the slow transient showed between-group motor adaptation differences: In the group where tones were triggered at the peak of the slow transient, force increased with between-action interval, whereas force did not change in the group with the initial transient-triggered tones. However, no between-group differences were found in the following sensorimotor sychronization task, that is, no transfer was found. This contradicts the assumption that synchronous action-tone events are encoded as action-effect events.

Poster #2.5: Successful visuo-motor predictions are supported by dedicated and flexible mechanisms

*Chiarelli Marco (1), Sertakan Hazal (1), Burr David (1), Cicchini Guido Marco (2)**

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2 - Institute of Neuroscience - CNR - Pisa (Italy)
**speaker*

Many everyday behaviors, from sports to smartphone use, require precise coordination between perception and action, often necessitating anticipatory mechanisms to compensate for neural processing delays. To investigate visuo-motor coupling, we presented participants with streams of moving stimuli and asked them to intercept targets as they passed through a virtual "gate". Cross-correlation analyses between stimulus trajectories and responses produced cross-correlograms characterizing the temporal dynamics of the visuo-motor loop. With preview information available, participants responded with near-optimal timing, approximating ecologically valid conditions of well-timed action. We then occluded portions of the stimulus stream preceding the required response. This manipulation revealed two key findings: first, participants maintained high performance even with very brief preview durations; second, they were able to effectively utilize preview information even if presented more than one second prior to action execution. Importantly performance remained robust across multiple preview–occlusion combinations, indicating a flexible predictive mechanism. Control experiments showed that these effects generalize across tasks and are not explained by previously described forms of temporal or spatial memory. All this novel evidence demonstrates the efficiency and flexibility of visual predictions over moderate time scales and pitches the idea that this fundamental function is subserved by an efficient and dedicated architecture.

Poster #2.6:Highway to heaven: visual-proprioceptive integration of steepness during uphill walking

Wünning Katharina (1), Ernst Marc (1)

1 - Applied Cognitive Psychology, Universität Ulm (Germany)

Advances in virtual reality have increased interest in studying active perception in interactive three-dimensional environments. Previous work on slope estimation under passive viewing conditions has shown systematic visual and proprioceptive biases in both real and virtual settings. Using a large

treadmill mounted on a 6DoF motion platform, we simulated sloped environments that participants could explore while walking. We examined visual and proprioceptive perception of uphill slopes during active movement. Participants provided verbal steepness estimates for slopes between 0° and 12°. In the visual condition, participants were passively moved over a virtual ramp; in the proprioceptive condition, they actively walked blindfolded on a tilted treadmill; and in the combined condition, both visual and proprioceptive cues were available. Across all conditions, slopes were strongly overestimated, even more than typically observed in real environments. Contrary to previous findings, the visual condition produced the largest exaggeration—nearly twice that of the proprioceptive condition. Combining visual and proprioceptive cues did not eliminate biases; bimodal estimates generally fell between unimodal estimates, suggesting weighted integration, yet remained highly exaggerated. Ambiguous sensory information shifted biases without a consistent preference for either modality. These results suggest that slant overestimation in VR may partly reflect distorted depth perception in VR. Understanding these perceptual differences between active and passive exploration may help improve spatial calibration and support the design of more perceptually accurate virtual environments.

Poster #2.7: A pleasant surface enhances motor efficiency during visuo-tactile mismatch

Kokkinou Dimitra (1) (2), Vlachou Maria Evangelia (1), Ackerley Rochelle (2), Aimonetti Jean-Marc (2), Blouin Jean (1), Mouchnino Laurence (1) (3)

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2 - Centre de Recherche en Psychologie et Neurosciences (France)
3 - Institut Universitaire de France (France)

Many studies have identified the neural signatures underlying touch interactions with the physical world, although the hedonic outcome of these interactions (i.e., the feeling of pleasure) and its impact on motor performance have received far less attention. To address this challenge, participants traced the contour of a complex shape with their index fingertip under mirror-reversed visual feedback. This manipulation, known to create a mismatch between visual and tactile inputs, reliably impairs performance compared to a direct-vision condition. A reduction in the difference between direct and mirror-reversed tracing performance would be predicted when the shape is presented on a pleasant, rather than neutral or unpleasant, surface, which would provide compelling evidence that hedonic valence can enhance motor efficiency. Preliminary kinematic analyses on motor performance (defined as the total tracing-length of the finger divided by shape length) conducted on n=14 participants showed a main effect of the tested surface (Mirror-Direct) ($F = 3.9$; $p = 0.05$). Post-hoc analyses further 2,11 revealed that performance was less impaired on the pleasant, compared with the unpleasant surface ($p = 0.04$). No significant differences were observed for the other comparisons. Our results suggest that the pleasant characteristics of the surfaces orient attentional resources toward hedonic-driven rather than motor-driven processes, thereby improving motor tracing performance. The pleasant surface being softer may also reduce mechanical interactions between the skin and the surface, potentially attenuating visuo- tactile conflict. Further analyses include EEG analyses of the visuo-tactile sensory cortical processing together with the assessment of mechanical stimulation evoked by skin/surface interactions.

Poster #2.8: Tactile and kinaesthetic contributions to the perception of novel objects: evidence for age-related compensatory mechanisms

Nevin Kate (1), Campogonara Ivan (2), O'Dowd Alan (1), Zumbrunn Nina Meret (3), Tsabary Canaan (1), Newell Fiona (1)

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2 - Zayed University (United Arab Emirates)
3 - Dublin City University (Ireland)

Haptic object perception relies on the integration of spatial information over time, involving cutaneous input from the skin (tactile) and the movement of the hand across the object (kinaesthetics and proprioception). It is known that the strategic deployment of stereotypical hand movements optimises the perception of specific object features (Lederman and Klatzky, 1987). Previously, we reported that an age-related decline in tactile sensitivity did not predict performance in the haptic discrimination of novel, 3D objects in which there were no age differences (see also Norman et al. 2006). This finding suggests that compensatory exploratory strategies during the acquisition of object shapes may preserve haptic object perception in older adults. To test this, we compared the hand movements deployed by younger and older adults during unconstrained haptic learning of novel objects. We used multiple cameras in a custom-made apparatus to record hand movements, and hand coordinates were then extracted using DeepLabCut models trained on pilot recordings from each camera. To aid our analyses, we computed shape indices of the individual object shapes. Principal component analyses were conducted to characterise the exploratory strategies across age groups. We will present evidence supporting age-related differences in exploratory movement patterns during the acquisition of objects. As before, no age differences in a subsequent recognition task were found. Our findings suggest that altered sensorimotor strategies may support preserved haptic object perception in older adults and have implications for our understanding of how top-down mechanisms guide active sensing in the perception of objects.

Poster #2.9: Visual and tactile processing: shared mechanisms for complex motion pattern analysis

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Orientation-dependent anisotropies such as the oblique effect — characterized by superior discrimination of cardinal compared to oblique orientations — are a well-established property of visual perception and have also been reported in static tactile tasks. However, whether this anisotropy extends to tactile motion perception and whether it depends on visual experience remains unclear. This study investigated tactile motion direction sensitivity across different reference orientations in sighted, early-onset blind, and late- onset blind individuals. Forty participants performed a two-alternative forced-choice task discriminating the direction of moving tactile gratings delivered via the RoMAT platform. Just noticeable differences (JNDs) were estimated from psychometric functions for three reference orientations. JNDs were analysed using linear mixed-effects models. Results revealed a significant main effect of Reference orientation, with lower JNDs for the horizontal direction compared to both oblique orientations, indicating higher sensitivity for cardinal motion. No significant main effect of Group emerged, and the interaction between Group and Reference did not reach significance. Crucially, the orientation-dependent anisotropy was consistently observed across sighted, early blind, and late blind participants. These findings demonstrate a tactile analogue of the

oblique effect in dynamic motion perception and show that this anisotropy does not depend on visual experience. The persistence of the oblique effect in both congenitally and late blind individuals suggests that orientation-dependent constraints in motion processing arise from intrinsic somatosensory or biomechanical factors rather than visual calibration. Together, the results support the view that fundamental computational biases in orientation processing are modality-specific and developmentally robust, extending beyond static perception to tactile motion.

Poster #2.10: Sensorimotor experience of the architecture tunes multisensory resource allocation in near and far space: behavioral and TMS exploration

Guerra Frey Giorgia (1) (2), Mastromarino Silvia (2), Fraghì Anna Laura (2), Sanchez Federica (3), Ramkumar Ashwanth (3), Avanzini Pietro (2), Bruno Nicola (1), Serino Andrea (4) (5), Vecchiato Giovanni (2) (6)

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Fronto-parietal networks encode multisensory representations of space to support physical interactions. Yet whether the surrounding environment and ongoing motor behavior shape these representations remains unclear. Building on recent evidence showing that virtual promenade modulates dorsal premotor cortex and that parietal motor rhythms encode architectural transitions, we hypothesized that these networks may be modulated by top- down environmental properties (indoor vs. outdoor) and bottom-up sensorimotor experience (static vs. dynamic). We used a multimodal stimulation paradigm in which participants responded to tactile stimuli delivered while a looming sound was perceived at six distances, from D1 (5 cm) to D6 (300 cm). Reaction time analyses revealed faster overall RTs in indoor environments. Static experience produced faster RTs from D1 (5 cm) up to D3 (125 cm), whereas dynamic exploration improved RTs at D6 (300 cm). This suggests increased salience of the location about to be reached. To probe neural mechanisms, we adapted the paradigm for transcranial magnetic stimulation (TMS). In the ongoing experiment, tactile stimulation is replaced by single- pulse TMS over the left primary motor cortex (M1) using four sound distances. Motor- evoked potentials (MEPs) are recorded from the first dorsal interosseous muscle and are expected to mirror behavioral results. Spontaneous EMG activity from the tibialis anterior will additionally provide an index of lower-limb engagement during virtual locomotion. Overall, multisensory processing is continuously tuned by action and context, with fronto- parietal circuits reallocating resources across near and far space to support adaptive behavior. TMS data will further clarify whether these distance-dependent patterns extend to corticospinal activity.

Poster #2.11: Investigating the role of visual and proprioceptive feedback in recognition memory during active and passive movement

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Handwriting is a powerful encoding strategy for new concepts and unfamiliar text. Writing involves constructing a motor plan, sending motor commands to the limb, and integrating reafferent visual and

proprioceptive signals from the moving limb. Whether this mnemonic advantage requires self-generated motor commands, reafferent sensory consequences, or a combination of both remains unresolved. To dissociate these contributions, neurologically healthy adults encoded novel Arabic words under four conditions that systematically varied motor engagement and sensory feedback: static viewing (no motor engagement, no dynamic visual feedback), dynamic viewing (visual reafference without motor engagement), passive writing (visual and proprioceptive reafference via robotic guidance, without volitional motor commands), and active writing (self-generated motor production with full reafferent feedback). Following encoding, participants completed a recognition test where they identified previously presented words among distractors. Recognition accuracy, reaction time, and confidence ratings (1–4 Likert scale) were recorded. Active writing produced the highest recognition accuracy, followed by dynamic viewing, passive writing, and static viewing. Confidence did not differ significantly across conditions, but was higher for correct than incorrect responses. Reaction time increased from active to passive writing to dynamic to static viewing, consistent with graded motor involvement. The recognition advantage of active writing over static viewing, combined with the near- equivalent performance of dynamic viewing and passive writing, suggests that self- generated motor production confers a mnemonic benefit that neither visual reafference nor passive proprioceptive input replicates. These findings provide evidence that active motor engagement, or the contingent coupling of efference and reafference, facilitates encoding of unfamiliar text.

Poster #2.12: Somatosensory processing during the planning of arm movements under gravitational force: a kinematic, EMG and EEG study

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The effect of gravitational force varies during arm ongoing movement, depending on the movement's orientation relative to the vertical gravity axis. This variation is most pronounced during vertical movements and negligible during horizontal movements. Previous studies have revealed that the CNS integrates this mechanical constraint during movement planning. Here we test whether proprioceptive feedback from the arm contributes to the adaptation of movement planning to the gravity field. Based on the premise that the cortical sensitivity increases with task-relevant sensory feedback, we hypothesized that the somatosensory cortex's response to vibration-induced stimulation of the shoulder muscles during movement planning would be greater for non-horizontal movements. With their right arm fully extended and initially pointing straight-head at shoulder level, participants (n=15) produced rapid arm movements to targets in different directions (vertical up and down, 45° up and down, horizontal) upon illumination. All targets required 45° shoulder movements. Kinematic, EMG and EEG data were recorded. The 200 ms-vibration of the anterior deltoid started 100 ms after target onset (i.e., 307 ± 0.02 ms before movement initiation). Compared to static control condition, source analyses of the EEG signals showed significantly greater somatosensory cortical response for vertical up movements and more insular cortex activity for vertical down and oblique movements suggesting that movement planning relies on direction-dependent gravitational reference frames. Also EMG and kinematic analyses indicated that participants exploited gravity to reduce energetic

cost, but at different levels. Future analyses will examine how cortical responses relate to kinematic and EMG patterns across movement directions.

Poster #2.13: Multisensory integration affects ocular and manual tracking differently

Jörges Björn (1), Kim John (1), Harris Laurence (1)

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Continuous psychophysics provides an elegant method for deriving the sensory precision with which a stimulus is represented from behavioral data. Continuous psychophysics is therefore well-suited for studying the advantages in precision conferred by multisensory integration. Here, we use continuous psychophysics to explore the relationship between manual and ocular tracking of visual, auditory and audio-visual stimuli. Two cohorts (n = 30 each) were immersed in a 3D virtual environment in which they tracked an object moving from side to side in front of them on a random walk using a hand-held controller while their eye movements were simultaneously recorded. No specific instructions were given regarding ocular tracking. We varied visibility using four levels of fog (including a condition where the target was invisible) and the object (a drone or a swarm of flies) could either emit a sound or be silent. As expected, behavioral variability in tracking, tracking delay and sensory precision were highly correlated between manual and ocular tracking. When looking at the advantage that adding sound to the visual stimulus provided, behavioral variability and sensory precision were also highly correlated between manual and ocular tracking. However, there was no correlation in this multisensory advantage for the tracking delay between manual and ocular tracking. That is, multisensory integration affected how fast participants reacted to changes in the stimulus differently depending on whether they tracked with their hands or with their eyes.

Poster #2.14: The predictive engine: how conscious experience and motor hierarchy drive sensorimotor timing

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1 - Peking University (China)

Sensorimotor adaptation is often characterized as an automatic or reactive process; however, with two studies, we demonstrate that precision timing is fundamentally a top- down, learned hierarchy. We first establish that the brain cannot calibrate its internal clock using subliminal, action-generated cues in isolation. Instead, the motor system relies on a "supraliminal scaffold"—prior conscious experience—to unlock the ability to utilize non- conscious information for temporal expectancy. This suggests that conscious awareness is the necessary catalyst for calibrating the predictive accuracy of the sensorimotor system. This cognitive priming is implemented through a proactive neural architecture where the motor system actively shapes sensory processing. In an MEG (Magnetoencephalography) study, we found that central to this mechanism is the supplementary motor area (SMA), which exerts a directional influence over sensory regions such as the superior temporal gyrus (STG) during temporal tasks. This motor-to-sensory hierarchy is supported by specific oscillatory markers—beta-band power modulation and contingent magnetic variation—which serve as the physiological bridge between interval perception and motor output. By shifting the paradigm from a reactive sensory model to a proactive, motor-led framework, these findings reveal that sensorimotor mastery is a high-level integration of learned conscious associations and top-down neural connectivity.

Sensory Impairment & Clinical Populations 1

Poster #2.15: Impact of congenital visual impairment on reach-to-grasp performance: an EEG study

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Congenital visual impairment (VI) alters the development of goal-directed actions, yet the neural mechanisms supporting these differences are not well understood. This study children with congenital VI compared with sighted (S) peers. Thirteen S children (7 females, age range: 1.4-5.3 years, mean age: 3.3 ± 1.2 years) and eleven VI children (6 females, age range: 0.7-5.3 years, mean age: 2.7 ± 1.5 years) completed a resting-state EEG recording and a reach-to-grasp task. Oscillatory (alpha1/alpha2, beta1) and aperiodic (1/f slope, intercept) spectral components were extracted from occipital (visual) and centroparietal (sensorimotor) regions. Only VI children showed age dependent EEG/behavior coupling: higher occipital alpha and central-parietal beta power predicted slower pickup times at younger ages but faster pickup times at older ages. Centroparietal 1/f slope showed an opposite developmental reversal. No corresponding effects appeared in S peers, nor for movement time. These findings indicate that resting-state neural dynamics relate specifically to grasp finalization in congenital VI and that their functional meaning shifts across early development, highlighting altered maturation of sensorimotor networks in the absence of visual input.

Poster #2.16: Investigating whether observing human and prosthetic hands engaging in painful and nonpainful actions affects touch

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Watching another's hand-object interactions evokes internal action representations in the observer, which includes simulating the predicted sensory outcome of the action. Previous research has found that observing another person's hand engaging in painful actions increases tactile detection and bias to report a stimulus. Would similar sensory predictions occur when watching the actions of a non-biological hand? As artificial hand technology develops, understanding action-representation and sensory predictions is important for fields such as prosthetics and wearable robotics. Therefore, we are exploring whether biological status and human-like appearance of a hand modulates sensory predictions. Our study will compare detection of tactile stimuli while observing human versus prosthetic hands (with realistic and mechanical appearances) grasping painful versus non-painful objects. We will use an Action-Pain-Observation paradigm with a 3x2x2 within-subjects design: Hand Type (Human, Realistic Prosthesis, Mechanical Prosthesis), Object Type (Painful, Non-painful), Action Type (Grasping, Withdrawing). Participants will view 2-frame sequences of a hand reaching towards and grasping/withdrawing from objects while reporting whether they receive a near-threshold tactile stimulus. Detection rates, false alarms, sensitivity (d) and response bias (c) will be compared. We will also explore individual differences: state and trait empathy, tendency to anthropomorphise and perceived closeness with the hands. We predict higher detection rates and a more liberal response bias

when observing all hands grasping painful vs non-painful objects. We predict this effect will be modulated by hand type, potentially being strongest in the human condition and weakest for the mechanical prostheses. Preliminary findings will be presented.

Poster #2.17: Pleasant touch promotes faster Braille reading

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Tactile input is essential for Braille reading, enabling the discrimination of the spatial and textural features of raised dots that encode linguistic content. This information is acquired through active exploration by sliding one or more fingers over Braille dots. We hypothesize that scanning more pleasant surfaces will increase Braille reading efficiency by promoting attentional focus on relevant external tactile cues rather than on movement execution, thereby reducing attentional demands of this sensorimotor task. Braille reading performance was assessed in 50 Braille readers (aged 20 to 74) using the standardized French version of the MNREAD test in Braille, printed on six different surfaces (aluminum, wood, PVC, paper, Dycem, and vinyl). Reading speed (characters per second), number of errors, and comprehension were measured. A pleasantness score was estimated individually for each surface. The effects of surface type and pleasantness scores on reading speed were estimated using linear mixed-effects models, while controlling for age of Braille learning and tactile acuity. We found significantly different reading speeds depending on the surface, with paper yielding faster performance (4.1 char/sec), followed by wood, PVC, vinyl, Dycem and aluminum (3.7 char/sec; $p < 0.001$). Surfaces rated as more pleasant yielded significantly faster Braille reading speed ($p < 0.01$). This effect remained consistent regardless of the surface. These findings suggest that the hedonic characteristics of surfaces orient attentional resources toward sensation-driven rather than motor-driven processes, improving Braille reading efficiency. This could help optimize Braille learning environments and design more engaging tactile reading materials.

Poster #2.18: Talk to the hand: auditory interface for the tactile bracelet

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To enable visually impaired users to autonomously utilize a tactile bracelet for grasping, we have developed an auditory interface that enables communication with the bracelet control system. Building on our previous research on the hand guidance using haptic signals, we developed and evaluated an automated system around the bracelet (HANS) that can detect and track target and distractor objects and guide the user without the assistance of an external operator in the navigation process. The auditory interface provides a final link between the user and the HANS, fully removing another person from the control loop. The auditory interface receives input from the user and passes it to the Large Language Model (LLM) that controls HANS via Model Context Protocol (MCP) tools. After successful identification of the user intent, the LLM is able to dynamically modify the currently tracked target object. This functionality is scalable as well to other high-level parameters of the system, such as bracelet vibration intensity, providing the option to adjust the system to the user's needs. Importantly, the LLM is able to retrieve the intent from the unstructured input, enabling the

interaction to occur in natural language. Overall, while our previous results showed that users can effectively use the bracelet with HANS to grasp target objects, our latest developments introduce a crucial option to control the system fully independently using voice commands. This is a critical step in the direction of moving the system out of the laboratory setup and testing it in more complex, real-world scenarios.

Poster #2.19: Individual differences in psychiatric and sensory traits modulate the perception of multisensory AI-generated advertisements

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Multisensory stimulation is omnipresent yet highly individual. What some experience as a coherent, immersive combination of stimuli, others may find distracting or overstimulating. Understanding these interindividual differences facilitates the design of sensory environments that accommodate diverse perceptual experiences. In the context of advertisements, which most of us encounter daily on smartphone screens, understanding these differences is fundamental for both users and advertisers. In this study, we examined how the perception of advertisement videos across multimodal conditions depends on sociodemographic factors (age, gender, education), smartphone usage habits, and psychiatric trait measures (depression, ADHD, autistic traits, sensory sensitivity). We employed an online study (n = 61) for stimulus selection and a laboratory study (n = 45), additionally incorporating olfaction. Participants were assessed on the aforementioned measures and then presented with a simulated social media feed containing AI-generated advertisement videos. Videos were presented alone or accompanied by semantically congruent music, odors, or both, and rated on advertisement-quality ratings, purchase intent, and perceived stimulus congruency. Using linear mixed models, gender emerged as a significant predictor, with women showing higher overall ratings compared to men. Higher autistic traits were associated with increased purchase intent, while depressive traits showed the opposite pattern. Generally, purchase intent was significantly modulated by perceived stimulus congruency. Interestingly, higher depression scores attenuated perception of audio congruency but enhanced odor congruency ratings. These findings suggest that while multisensory stimulation generally enhances advertisement engagement, its effectiveness depends on both the perceived congruency of the sensory stimuli and individual characteristics of the target audience.

Poster #2.20: Multisensory stimulation with rave restores visual function in hemianopic patients

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Strokes of the posterior cerebral artery that cause unilateral damage to posterior occipital cortex can result in a permanent blindness in the opposite hemifield (hemianopia) or in one quadrant (quadrantanopia). These conditions are devastating to quality of life and functional independence of patients and are highly resistant to existing treatment options. Recent work in a preclinical animal model developed a specific multisensory (visual-auditory) exposure protocol that was demonstrated to restore visual responsiveness in residual circuits after cortical lesions, as well as visually guided behaviors in the blinded field. We conducted a pilot study in adult humans with unilateral blindness resulting from stroke using this intervention and identified substantial improvements in visual function

(detection and localization of stimuli throughout the previously blind hemifield) following a 10-week minimalist intervention (one visit / week). Outcomes were assessed using a novel virtual reality testing paradigm (Unreal Engine) that tracked the trajectory of recovery. Improvements in the visual field were typically seen within a few sessions/weeks and continued to improve over later weeks. The final disposition of the visual fields was remarkably improved over baseline, and there were concomitant significant and meaningful changes in patient quality of life. These findings suggest that multisensory plasticity can be engaged to rehabilitate blindness following stroke in adults.

Poster #2.21: Early multisensory stimulation to promote visual field recovery after stroke: incidence, neural correlates, and clinical implications

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Multisensory integration plays a crucial role in perception, spatial awareness, and adaptive behavior following brain injury. This study aims to quantify the incidence and severity of visual field deficits in individuals with a recent cerebrovascular event and to evaluate the effectiveness of an early, intensive, and systematic multisensory rehabilitation intervention in reducing post-stroke visual field impairment. Furthermore, the study explores the role of multisensory integration mechanisms in promoting functional recovery. In the retrospective phase, the incidence of visual field deficits will be assessed in 800 patients, analyzing lesion location, stroke type, and treatments administered. In the prospective phase, hospitalized patients will undergo early visual field screening using wearable parametric devices. The experimental group will receive early visual training based on multisensory stimulation, while the control group will be monitored for spontaneous recovery. The analysis will examine correlations between visual field deficits, lesion sites, and clinical severity scores (NIHSS, Rankin, ASPOS). Preliminary medical record analysis shows a 48.5% incidence of visual field deficits in stroke patients, higher than commonly reported in the literature, with rates of 61% in hemorrhagic stroke and 46.5% in ischemic stroke. These findings highlight the clinical relevance of post-stroke visual deficits, particularly hemianopia, a frequent yet challenging condition to assess at the bedside. The ongoing prospective screening will provide a detailed evaluation of the relationship between lesion location, clinical severity, and visual deficit profiles, enabling comparison between multisensory stimulation and spontaneous recovery.

Poster #2.22

Poster #2.23: Improving sensorimotor skills through laterality-based intervention in children with and without motor impairments

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Pediatric stroke is a leading cause of disability in developed countries1, disrupting sensorimotor coordination, goal-directed actions, and lateralization. MSICLIMB is a multisensory climbing wall developed for assessment and promotion of sensorimotor training through ecological, engaging tasks2. Active sport-based tasks have been shown to support psychomotor development in children with motor deficits. Here, we used MSICLIMB to implement a reach-to-grasp task in the extra personal space where targets provided auditory, visual, or multisensory cues. Analyses compared task performance between 52 children with typical development (TD; 4–13 years, mean = 7.5(2.6)) and 33 children with motor impairments (4–13 years, mean = 8.7 (2.6)), or for intragroup analyses, a subgroup of 24 children after excluding participants with lower-limb deficits, focusing on reaching time and success rate across different regions of interest (ROI). ROI analyses (central, right, left, ipsilateral/contralateral to the lesion) revealed that TD children exhibited a consistent leftward bias ($p < 0.001$), known as pseudoneglect. Importantly, multisensory cues mitigated this bias, balancing both accuracy and response patterns (RT multisensory $p < 0.001$; Success Rate multisensory $p < 0.001$). Children with motor impairments showed significant improvement in success rate for multisensory ($p < 0.001$) cues in contralateral space, suggesting that multisensory stimulation can promote compensatory motor strategies. These effects were particularly pronounced in targets opposite the affected side, highlighting the role of laterality-specific interventions. Overall, our findings highlight the potential of multisensory, laterality-specific approaches in pediatric motor training and early intervention, supporting ecologically valid training devices for pediatric intervention.

Poster #2.24

Poster #2.25

Emotions & Aesthetic Perception

Poster #2.26: Effects of skin physical properties and contact-evoked skin vibrations on subjective pleasantness and EEG responses

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Affective touch perception arises from the interaction between physical properties of the skin, stimulus-induced mechanical inputs, and neural processing. However, how these multidimensional factors jointly shape pleasant and unpleasant tactile experiences remains poorly understood. This study investigated the physiological and neural bases of affective responses to tactile stimulation using two contrasting materials: fur, which typically elicits pleasant sensations, and plastic turf, which produces unpleasant sensations. During passive stroking of the left index finger, we measured EEG

activity, fingertip skin vibrations, and subjective pleasantness ratings. In addition, participants' skin biophysical properties were assessed beforehand using cutaneous probes that quantified viscoelasticity, hydration, friction, indentation, and sebum levels. Subjective ratings confirmed a clear affective contrast between the two stimuli, with fur rated as markedly more pleasant than turf. Skin vibration analyses showed that plastic turf induced stronger power in the 40–60 Hz band and higher principal component scores, and these vibration components were negatively correlated with perceived pleasantness under the turf condition. EEG source-level time–frequency analysis identified material dependent modulation in the superior parietal cortex, which exhibited significantly stronger event related spectral perturbations for turf in both early and sustained -periods of stimulation, whereas no significant differences appeared in bilateral S2 or SMA clusters. Finally-, an exploratory correlation analysis integrating all measurements allowed us to visualize the relationships among skin properties, mechanical vibration, neural responses, and affective evaluations. These findings provide a multidimensional characterization of how physical and physiological factors jointly contribute to pleasant and unpleasant tactile experiences.

Poster #2.27: Near advantage in unfamiliar voice recognition

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Given the enhancements of perception and attention within the peripersonal space, it is hypothesized that sound source distance affects higher functions of cognitive processing. This study examined whether the distance during encoding and recognition phases affects recognition memory performance for unfamiliar voices. Voice stimuli were created with binaural recordings at near and far distances. Participants performed a recognition task in which the distance of voice stimuli was independently manipulated during the encoding and recognition phases. The results showed that voices presented at a near distance in the encoding phase were recognized more accurately than those presented at a far distance, whereas the voice distance during the recognition phase did not affect the performance. In addition, no effect distance on perceptual processing of was observed. These findings show a novel cognitive advantage in near space around the body and suggest that the influence of proximity arises from encoding, but not retrieval, process of recognition memory.

Poster #2.28: A more differentiated representational structure of emotion in multisensory than unisensory perception

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Emotion recognition is a core component of social communication, yet most work has focused on visual expressions, leaving less understood how emotion representations are organized across other modalities. The present study used representational similarity analysis to examine modality-specific differences in the structure of emotion recognition, with particular emphasis on whether audiovisual cues more closely reflect a coherent, modality-general emotion space. Participants completed an emotion recognition task in which emotions were presented in auditory, visual, and audiovisual formats. Confusion matrices were computed for each modality and converted into representational dissimilarity matrices. Hierarchical clustering was used to identify emotion groupings, and

multidimensional scaling was conducted to visualize the structure of emotion space within each modality. The audiovisual condition showed the greatest degree of category distinctiveness, with most emotions remaining relatively well differentiated and only a few small groupings appearing consistently across clustering approaches. The visual condition produced broader clusters organized largely by valence, whereas the auditory condition yielded the least differentiated structure, with broader groupings that extended across valence boundaries. To assess whether a shared, modality-independent emotion space could be identified, a central representational structure was derived and compared with modality-specific structures. The audiovisual condition showed the strongest alignment with this shared structure, indicating that it most closely approximated a common organizational geometry of emotion perception. Cross- modal comparisons further showed strong correspondence between audiovisual and visual structures, whereas auditory structure was comparatively divergent. Together, these findings indicate that multisensory emotion cues promote more differentiated and stable representational organization than unisensory cues alone.

Poster #2.29: Cross-sensory correspondences between touch, smell and emotion: developmental differences in associations and explanations in pre-schoolers and adults

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**speaker*

Cross-sensory correspondences are systematic associations between features across sensory modalities. A well-known example is the Bouba–Kiki phenomenon, wherein the word “bouba" is associated with rounded shapes and "kiki" with angular shapes (Ramachandran & Hubbard, 2001). In cases regarding visual-auditory correspondence, evidence shows that such correspondences are robust across cultures and age groups (Ćwiek, 2022). However, cross-sensory correspondences in other modalities, such as smell, touch, and emotion, are less well studied. In particular, we lack evidence about differences in sensory correspondences across age groups and how individuals rationalise associations. To address this gap, we compared cross-sensory correspondences in preschool children (ages 2–4, n = 26) and adults (ages 18–28, n = 26) using a controlled one-to-one experimental protocol. Participants explored tactile stimuli and matched them to linguistic labels, olfactory stimuli, and emotional states, then explained their choices. To examine cognitive representation and justification, we analysed the "association strategies" present in participants' responses. Across both groups, some correspondences were consistent: participants corresponded the spiky shape with lemon scent, the rounded shape with vanilla, and lemon with excitement. We also saw evidence of developmental differences. Preschool children showed different tactile-emotion correspondences than adults and largely explained choices by recourse to concrete reasoning and familiar experiences, whereas adults used a wider range of strategies. Children also produced fewer and shorter verbal rational, suggesting that some correspondences may operate intuitively before becoming explicitly articulated. Our findings demonstrate both continuity and developmental change in cross-sensory cognition and suggest that explanatory strategies become more abstract with age.

Poster #2.30: Postural responses during emotion recognition: the role of face orientation and individual differences

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The body plays a central role in understanding one's own mental state and that of others, which is essential for social interactions. Exposure to emotional facial expressions can be associated with body reactions such as reduced or increased postural sway depending on the expressed emotion. Moreover, recognition of facial emotions is affected by the orientation of the face; in fact, face inversion influences the accuracy of recognition. This effect is not uniform; there are more sensitive emotions such as anger, disgust, and fear, whose recognition decreases when the face is inverted. In the present study, we aim to verify: 1) whether postural parameters (i.e., Center of Pressure) change during the performance of an emotion recognition task while standing on a force-sensing platform with a foam pad placed to reduce proprioceptive cues; 2) how different degrees of orientation of the face impact emotion recognition and postural response. In addition, we investigate whether these variables are influenced by individual factors such as state anxiety, alexithymia (i.e., difficulty in recognizing emotions), and theory of mind (ToM) ability (i.e., recognition of others' mental states). Response to different degrees of face orientation shows a pattern of increasing difficulty in recognizing emotions as face orientation approaches inversion. In line with previous literature, this pattern is influenced by individual factors: the level of anxiety influences recognition of negative emotions and associated postural sway. Regarding ToM, individual differences in this ability predict emotion recognition, and this relationship is also reflected in the body response measured through postural sway.

Poster #2.31: Emotion concepts, facial expressions, and affective vocal bursts: mapping colour to emotion across modalities

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Existing literature brings strong evidence for universal colour-emotion correspondences. For instance, lighter and more chromatic colours are perceived as more positive, while darker and less chromatic colours – as more negative. However, to study colour-emotion links, nearly 80% of previous studies used emotion words, with facial expressions being the second but much less prevalent choice (14%). No study considered vocal expressions, despite their central role in affective communication, and none compared the stability of colour-emotion associations across emotion modalities. To bridge this gap, we had 157 participants (M=25, F=131, NB=1; M =21.4) view 17 emotion expressions from the age GEneva Multimodal Emotion Portrayals database (GEMEP), presented in one of the three between-subject conditions: emotion words (n=55), dynamic facial expressions (n=51), or vocal bursts (n=51). Participants chose the best colour for each expression from an unrestricted colour range. Only seven emotions were recognised by at least 70% of participants in facial and vocal conditions and kept for analysis. Overall, colours differed between emotion modalities in hue and chroma, but not lightness (CIE LCh colour model). For instance, vocal bursts were matched to the most chromatic colours. There were also significant interactions between modality and emotion category in lightness (for relief, surprise), chroma (for relief, surprise, irritation, fear, anger) and hue (for irritation, fear, relief, surprise). All results suggest that colour-emotion correspondences are not independent of emotion modality. The next question is whether perceptual features of stimuli (e.g., pitch) map onto colour directly, complementing the conceptual colour-emotion associations.

Poster #2.32: The power of audio-visual cues for assessing haptic qualities in clothing e-commerce

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The absence of physical touch remains a critical limitation in clothing e-commerce, reducing consumers' ability to evaluate material properties and engage affectively with products. This research investigates how sensory compensatory cues – visual (static versus dynamic imagery) and auditory (congruent versus incongruent touch-produced sounds) – shape tactile engagement, product evaluation, and purchase intention in simulated clothing e-commerce. Across two studies, dynamic visual motion enhanced tactile engagement, product evaluation, and purchase intention, particularly for fabrics with visually ambiguous textures such as Cashmere. Congruent audio-visual pairings further increased pleasantness, comfort, and perceptual fluency, whereas incongruent or temporally misaligned sounds disrupted sensory coherence and amplified perceptions of roughness. The findings demonstrate that the effectiveness of multisensory design depends not on the number of sensory cues provided but on their temporal and semantic coherence. By connecting principles of multisensory perception with consumer judgment, this research advances understanding of how perceptual alignment fosters tactile vividness, emotional resonance, and sensory trust in clothing e-commerce.

Multisensory Processes & Learning

Poster #2.33

Poster #2.34: Effects of audio-visual presentation timing on visual search performance in virtual reality

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In virtual reality (VR) environments, auditory feedback that reflects user actions has the potential to enhance the efficiency of VR tasks, including visual object searches, as shown by several recent studies. In our previous study, we developed a VR auditory display using HRTF synthesis, and investigated the effects of auditory feedback on visual object search performance in VR. The results suggest that spatialized auditory cues, rather than semantic content or sound type play an important role in facilitating visual search. However, in most previous studies, auditory feedback was presented simultaneously with visual stimuli. Moreover, the effects of audiovisual presentation timing on search performance have not been sufficiently clarified. Therefore, we reconstructed the VR auditory display to examine the effects of auditory feedback by widely manipulating the temporal relationship between the auditory and visual stimuli. Experimental results revealed that the effects of auditory feedback were hardly noticeable within the central visual field and the effective visual field (within ±35°), but became pronounced outside the effective visual field. In particular, when auditory feedback was presented ≥300ms before the visual stimulus, the search time was significantly reduced. By contrast, when auditory stimuli were presented after the visual stimulus, search time increased. This effect became more pronounced in the peripheral visual field (±60°) and near the maximum visual

field (±100°). Under the simultaneous-presentation condition, the search time was shorter than that under the delayed-presentation condition; however, no significant improvement was observed compared with that under the advance- presentation condition.

Poster #2.35: Implicit vs. Explicit practice of structured piano sequences: performance and retention outcomes

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Music performance integrates auditory, visual, and motor information, serving as a key area for studying multisensory support of skill acquisition. An important challenge in motor learning is identifying practice conditions that optimize both acquisition and long- term retention, yet few studies have compared implicit and explicit learning using a complex, ecologically valid multisensory task. This study examined how practice structure influences the learning and retention of musical sequences in novice participants. Two groups of participants (n = 43) completed a two-day practice protocol using either an implicit or explicit practice paradigm. The implicit practice group performed 150 randomized trials wherein a repeating target sequence was embedded among distractor and free-play trials. The explicit practice group completed 150 trials in 10 sequence-specific blocks of 15 and received note-accuracy feedback every five trials. Accuracy and asynchrony were assessed immediately and 24-hours after practice, followed by a transfer test involving a novel sequence. Both implicit and explicit practice groups significantly improved in accuracy and asynchrony from acquisition to the delayed retention test. The implicit practice group also showed significant improvements in accuracy and asynchrony from acquisition to immediate retention. For accuracy, between-group comparisons revealed that the implicit group were more accurate than the explicit group in the immediate retention test. Together, these findings demonstrate that both implicit and explicit practice structures support the learning and retention of musical sequences in novice performers. Notably, the accuracy results suggest that implicit practice may promote more robust early learning compared to explicit practice.

Poster #2.36: Cross-modal serial dependence

Zaidel Adam (1)

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Serial dependence is often studied within a uni-modal context – primarily, vision. However, our experience of the world is naturally multisensory. In a series of recent studies, we tested – specifically, in visual-vestibular perception of self-motion, and visual-auditory temporal perception. Moreover, we examined how external feedback modulates serial dependence. Across experiments, we systematically found that two primary factors of recent history – the previous stimulus, and previous choice – differentially affected subsequent perceptual decisions. In general, previous stimuli led to negative (repulsive) effects, while previous choices led to positive (attractive) effects. Cross-modally, serial dependence was seen for visual-vestibular self- motion perception. Specifically, previous stimuli elicited a repulsive effect on the subsequent perceptual decision, in both uni-modal and cross-modal conditions. In follow up experiments, we found that this repulsive effect of prior stimuli remained even when attention was diverted away from the previous stimuli (using a distractor task). In terms of external feedback, the attractive effects of prior choices (without feedback) were unaffected by feedback for correct choices. By contrast, feedback for incorrect choices led to choice switching – both

within and across modalities. In two other cross-modal studies, of audio-visual temporal perception, repulsive effects of previous stimuli were seen only in the uni-modal, but not cross-modal, conditions, and surprisingly, a repulsive effect of previous choices emerged cross-modally. In this talk, I will present the various results from these studies, and discuss what can be learned from the presence or absence and different types of (uni-/cross-modal) serial dependence.

Poster #2.37: Learning associations between unfamiliar auditory and visual stimuli

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Perception and cognition often depend on associations learned between stimuli from different sensory modalities, such as where we can detect dogs via their barks or anticipate how seen objects will feel. Surprisingly, we know little about our capacity to learn these associations, whether this depends on cross-modal congruence, and if the type of association (e.g., linguistic, non-linguistic) matters. First, we developed a large set of unfamiliar yet naturalistic auditory-visual stimuli: visual objects were AI-generated images, while sounds were pseudowords or unfamiliar environmental-like sounds created by editing the spectral and/or temporal features of natural sounds. We then assessed learning of auditory-visual associations in an explicit single-trial memory task (Experiment 1) and in a more implicit statistical learning task (Experiment 2). Experiment 1A measured unimodal recognition memory for familiar and unfamiliar auditory and visual stimuli. In Experiment 1B, unfamiliar auditory and visual stimuli were paired randomly and presented once each during a study phase; later, participants discriminated studied auditory-visual pairings from new auditory-visual pairings before rating how subjectively congruent each auditory-visual pairing was. Cross-modal association memory was above chance but was equally poor for linguistic and non-linguistic associations, while higher cross-modal congruence was associated with better association memory. Experiment 2 required participants to learn auditory-visual associations by tracking conditional probabilities across trials, with data analysis to be completed by mid-year. We have quantified, for the first time, cross-modal association learning in explicit and implicit learning contexts, with results suggesting that incidental cross-modal congruence facilitates learning.

Poster #2.38: Applying multisensory methods to understanding the structure of visual quantity estimation

Negen James (1)

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There is an ongoing debate about whether vision first estimates number and area (convex hull), deriving density later by division, or if vision first estimates density and area, deriving number later by multiplication. This poster reports two experiments that apply methods from multisensory research to this debate. The first used methods from multisensory cue combination studies. Participants choose the stimulus with greater area, greater number, or both. There was no advantage for having both. This is easier to explain under the density first theory, which implies that area perception and number perception have correlated errors. The second experiment used methods from multisensory forced fusion studies. Participants were shown three clouds of dots where two clouds were equal in density, area, and number. They were asked to find the oddball. Preliminary results suggest there is a congruency effect between area and density i.e. it is easier when both are greater or both are lesser than the matching standards. However, there appears to be an anti-congruency effect for area and

number: performance is better when one is greater and the other is lesser. This is also easier to explain under the density first theory as it matches the predictions and results from multisensory studies where we know the two cues are not derived from each other. These experiments illustrate how multisensory methods can be useful for wider debates in cognitive science.

Poster #2.39: Spatial but not temporal crossmodal recalibration is context-specific

Kocak Batuhan A. (1), Röder Brigitte (1) (2), Bruns Patrick (1)

1 - Biological Psychology and Neuropsychology, University of Hamburg, Hamburg (Germany)
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When auditory and visual stimuli are presented with a spatial or temporal discrepancy, stimulus processing is typically adjusted to correct for this mismatch in a process called crossmodal recalibration. Though generally assumed to be a transient effect, some studies have demonstrated persistent spatial recalibration effects over repeated sessions, suggesting that adjustments of sensory representations might be stored and reactivated in a context-specific manner. Here, we directly tested the context-dependence of both spatial and temporal crossmodal recalibration. In two experiments, participants went through pretest blocks in a "contextless" environment (empty background), followed by adaptation and immediate posttest blocks in two experimental contexts, and an additional delayed (5-10 minutes) posttest block in each context. This allowed us to investigate whether sensory adjustments observed in immediate posttests directly after adaptation transfer to delayed posttests based on contexts. In Experiment 1 (spatial recalibration), contexts (different rooms in virtual reality) were associated with opposite audiovisual spatial discrepancies (leftward vs. rightward) during adaptation. Indistinguishable recalibration of unimodal sound localization was observed in immediate and delayed posttests despite the break, indicating context-specific crossmodal recalibration of auditory spatial maps. In Experiment 2 (temporal recalibration), contexts (colored frames around the screen) were presented with two different stimulus onset asynchronies. While audiovisual simultaneity judgments in immediate posttest blocks indicated successful crossmodal recalibration, these adjustments had dissipated at the delayed posttests, and thus were not reinstated based on context. Taken together, these findings suggest that crossmodal recalibration in the spatial domain is context-specific and thus longer-lasting than in the temporal domain.

Poster #2.40: The precision of virtual reality systems for multisensory research

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The use of virtual reality (VR) for human psychophysics provides researchers with an exciting, accessible, and transformative tool to assess multisensory integration in more complex, naturalistic, and yet carefully controlled conditions than those normally available in real-world experimentation. However, previous research has identified important limitations of VR paradigms for psychophysical tasks used in multisensory research; principally, limitations on the timing fidelity with which spatialized visual and auditory stimuli can be presented. In previous reports, trial-by-trial variability (error) in the actual delivery of visual and auditory stimuli intended to be "synchronous" can be on the order of tens of milliseconds. This error, which is not always tracked or obvious to the researcher, can nevertheless corrupt evaluations of multisensory integration and the effectiveness of applications that require precise stimulus control. Fortunately, this error can be greatly reduced to

psychophysically acceptable levels with appropriate hardware and software approaches. We present results from a VR experimental setup that leverages the Unreal Engine 5.3 framework and a Pimax Crystal Super Ultrawide headset with an integrated software stack. Photodiode and microphone recordings conducted at 9500Hz reveal that, when appropriately calibrated and programmed, this paradigm minimizes visual and auditory timing error to a maximum of a few milliseconds. We then extend this experimental setup to incorporate the high- resolution eye tracking capabilities of the helmet and illustrate how it can be deployed to assess multisensory integration in a complex, real-world environment.

POSTER SESSION 3

JUNE 26th | 10:30 am – 11:45 am

HALL

Spatial and Motion Perception

Poster #3.1: Sustained auditory spatial attention facilitates visual processing

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Spatial attention coordinates the integration of multi-sensory inputs. For example, transient peripheral sounds reflexively attract spatial attention and enhance visual processing at the congruent location (Keefe & Störmer, 2021). Yet, how intentional, sustained spatial attention to sounds shapes visual perception remains largely unknown. To address this gap, we conducted behavioral and electroencephalography (EEG) study, combined with dichotic listening paradigm. Subjects listened to two voice streams of digits were played from speakers located at the left and right sides of a monitor. Prior to each block, subjects were instructed to attend to (1) the left speaker, (2) the right speaker, or (3) a specific voice gender (male/female) and to perform auditory 1-back task (detect immediate digit repetitions) while maintaining central fixation. In the behavioral experiment, a sub-threshold Gabor patch flashed intermittently in either visual hemifield, and participants reported its orientation (clockwise vs. counterclockwise). We found higher visual discrimination accuracy for visual stimuli presented in the hemifield matching the attended speaker location. In the EEG experiment, participants passively viewed two task-irrelevant checkerboard patterns presented to the left and right of fixation, flickering at different frequencies (12 Hz and 15 Hz). Analysis of steady-state visual evoked potentials (SSVEPs), a signature of early visual processing, revealed larger amplitudes for the visual stimulus located on the same side as the attended auditory stream. Together, the behavioral neural evidence demonstrates that sustained, volitional auditory spatial attention selectively boosts visual processing at the corresponsing spatial location, highlighting robust cross-modal interaction under prolonged spatial attention.

Poster #3.2: Are there specialized mechanisms for auditory motion detection? Evidence from a reverse-correlation psychophysical paradigm

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2 - Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia, Genova (Italy)
3 - The University of Sydney (Australia)
4 - LSP, Ecole Normale Superieure, Paris (France)

The existence of specialized mechanisms for auditory motion detection remains a central question in spatial hearing research. Influential work by Fine&Park suggests that auditory motion perception may emerge from spatiotemporal integration of sequential spatial samples rather than from dedicated motion-sensitive detectors. We test this hypothesis using a psychophysical paradigm designed to reveal perceptual signatures consistent with motion- selective mechanisms. Participants were presented with band-pass noise stimuli delivered through a multi-speaker spatial array. Apparent

motion trajectories (leftward and rightward) were generated via rapid amplitude transitions across adjacent loudspeakers, while spatially distributed Gaussian noise masked simple onset and localization cues. We analyzed responses using a reverse-correlation framework. This approach enables reconstruction of spatiotemporal perceptual kernels, while spatially localized models would support alternative models based on sequential position sampling. The presence of structured diagonal patterns in these kernels would provide evidence consistent with motion-selective mechanisms. Preliminary results show robust direction discrimination but weak and inconsistent diagonal structure in the reconstructed perceptual kernels. Ongoing data collection aims to increase statistical power across configurations to determine whether the observed patterns reflect methodological limitations or the absence of specialized auditory motion detectors.

Poster #3.3: Metaperception in auditory-driven bias of perceived locations

Lorca-Vyhmeister Alejandro (1), Mamassian Pascal (1)

1 - École normale supérieure (France)

To efficiently interact with the world, we constantly integrate different sensory cues and engage in metaperceptual processes to judge the validity of the resulting multisensory percepts. Here, we are interested in the metaperception of an auditory-driven bias on perceived positions of a visual flash. In our audiovisual paradigm, the visual stimuli were three Gaussian blobs presented successively at three vertically aligned positions. Auditory stimuli were pure tones. The first and third visual and auditory stimuli were synchronised and separated by 467ms. The second flash was presented at one of five possible positions near the spatial midpoint, and always halfway in time (233ms). The time of the second tone could start early, synchronous, or late relative to the second flash (at 167, 233, or 300ms). A no-sound condition was also added as a baseline. Participants reported the perceived position of the second flash with the computer mouse. After their perceptual decision, participants used a continuous scale to provide a confident judgment on their perceptual accuracy. As expected, reported positions of the second flash followed physical positions, with some regression to the mean of the five perceived positions. Importantly, early tones created a spatial bias towards the first flash, and reversely for late tones. For each flash position condition, confidence judgments were higher for perceptual reports closer to the median position for that condition, thereby revealing metacognitive sensitivity. Finally, no differences were observed in metacognitive sensitivity across all sound conditions, indicating that participants cannot detect visual spatial biases induced by a sound.

Poster #3.4: Stimulus-driven representations of auditory, visual, and audiovisual motion

Tiesman Adam (1) (2), Bertisch Hannah (2), Stoyanova Kalina (2), Ramachandran Ramnarayan (1) (3), Wallace Mark (1) (2)*

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3 - Vanderbilt University Medical Center, Nashville (United States)
**speaker*

The ability to perceive auditory and visual motion cues is essential for survival. Perception of audiovisual (AV) motion direction is dependent on many stimulus statistics including modality, motion strength (coherence), and congruence across modalities. However, there is little empirical evidence showing how and when AV motion statistics modulate neural activity. This study examines how stimulus statistics influence both behavioral and neural responses to auditory, visual, and audiovisual motion. Participants (n=12) were presented with either leftward or rightward motion that

could be visual, auditory, or combined AV, and electroencephalographic (EEG) responses were recorded under passive conditions. Mixed-effects models were employed to analyze how motion coherence related to event-related potential (ERPs) amplitude, and how modality related to ERP latency. Topographic and frequency analyses (e.g., alpha-band power) supported modality-specific contributions to the audiovisual motion signal, providing insight into how the brain integrates motion information. Consistent with behavioral measures, we found that both congruent and incongruent auditory motion enhances visual motion representations. Notably, AV signals appeared to combine the auditory and visual ERP components linearly. Passive EEG results were then compared to an active condition, where participants reported motion direction. The study suggests that motion strength is well correlated with neural signatures of motion perception, but not for congruence between modalities. These findings are the first steps of our investigations on the neural correlates of motion processing and attention, and for future work on understanding how these neural signatures relate to sensory conditions such as hearing loss. This research was supported by an unrestricted gift from Reality Labs Research, a division of Meta.

Poster #3.5: Motor-proprioceptive training promotes spatial hearing restoration in disrupted auditory conditions

Camponogara Ivan (1)

1 - Zayed University (United Arab Emirates)

Actively moving a hand-held sound source can restore auditory localization in disrupted auditory conditions. However, whether this restoration is driven by the coupling of auditory information with motor-proprioceptive signals or with proprioception alone remains unclear. Here, 62 participants performed right-hand reaching to sounds positioned along the azimuthal plane under binaural and left monaural conditions (disrupted hearing). Then, they were randomly assigned to one of four training groups and re-tested after a 10-minute training consisting of: (1) passive listening to a moving source, (2) active movement of the source by holding it (auditory-motor-proprioceptive), (3) listening to static sounds alone or while (4) holding it (audio-proprioceptive). Active movement led to an overall 70% restoration of localization accuracy and a 30% advantage over passive movement on the impaired side. Crucially, pairing proprioception with a static source produced no benefit, suggesting proprioceptive signals must co-occur with movement-related signals for auditory restoration. A follow-up experiment tested whether haptic inputs arising from physical contact with the speaker are fundamental to auditory restoration. Participants (n = 13) remotely guided the speaker by hovering their hand above it, preserving motor-related proprioception while eliminating haptic input from direct contact. Hovering led to an overall 50% restoration of localization accuracy on the impaired side, though performance was between active movement and passive listening. Proprioceptive-motor signals alone thus appear sufficient to drive restoration, though full haptic contact further enhances it. Together, these findings suggest that auditory spatial restoration stems from the coupling of auditory inputs with movement-related proprioceptive signals.

Poster #3.6: Efficient integration of multisensory spectral cues for spatial hearing

Ernst Marc (1), Oess Timo (1), Neumann Heiko (2)

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2 - Institute of Neural Information Processing, Universität Ulm (Germany)

Perception often requires resolving ambiguities in sensory signals. In vision, for example, the retinal image alone is insufficient to determine an object's size because different combinations of size and distance can produce the same projection. The visual system resolves this ambiguity by integrating additional cues such as binocular disparity, motion parallax, and prior knowledge. We propose that the auditory system faces an analogous challenge when estimating the elevation of a sound source. The sound spectrum measured at the eardrum reflects both the original spectrum of the source and direction- dependent filtering by the listener's head and ears, described by the head-related transfer function (HRTF). Because both factors are typically unknown, inferring sound direction from the observed signal constitutes an ill-posed inverse problem. Here we show that the auditory system resolves this ambiguity by combining multiple sources of information. First, binaural comparisons between the two ears provide a representation that is largely independent of the sound source spectrum, enabling more reliable extraction of elevation cues. Second, prior knowledge about the spectral structure of familiar sounds contributes to localization, although its influence is relatively modest. Third, short head movements introduce parallax that further aids disambiguation by separating stable source characteristics from direction-dependent filtering. Behavioral experiments demonstrate that elevation localization becomes extremely difficult under monaural listening conditions with unfamiliar sounds and a stationary head, but improves dramatically with binaural listening. Familiarity and small head movements provide additional benefits, whereas larger movements do not. A Bayesian model integrating binaural cues and spectral priors accounts for these results. Together, these findings suggest that spatial hearing relies on cue integration strategies analogous to those used in vision to resolve sensory ambiguity.

Poster #3.7: Investigating the influence of visual experience on the central tendency bias in horizontal and vertical acoustic localization

Esposito Davide (1), Tonelli Alessia (1) (2), Calafatello Gloria (1) (3), Gori Monica (1)

1 - Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia (Italy)
2 - The University of Sydney (Australia)
4 - Università degli Studi di Genova (Italy)

Auditory localization is often subject to a central tendency bias, where perceived positions regress toward the mean of the stimulus distribution. While blindness is known to induce neuroplastic changes, it remains unclear whether the timing of vision loss specifically modulates this regression across different spatial dimensions. This study investigated the magnitude of regression to the mean in the egocentric localization of static sounds along the horizontal and vertical planes among early blind, late blind, and sighted adults. 37 participants (11 early blind, 12 late blind, 14 sighted) localized sound sources coming from a speaker array lying along the vertical or the horizontal axis in randomized order. Regression to the mean was quantified by analyzing the slope of the localization error. Our findings reveal a robust consistency across populations. On the horizontal plane, all three groups exhibited high accuracy with no significant regression to the mean. In contrast, in the vertical plane all three groups exhibited a significant and consistent central tendency bias. Crucially, no significant differences were found between the three groups within either plane. The only significant effect observed was the dissociation between planes, with vertical localization showing markedly higher regression compared to horizontal localization across all subjects. These results suggest that the mechanisms underlying audio-spatial regression to the mean are independent of visual experience or its onset. The stability of horizontal mapping and the inherent susceptibility of vertical mapping to statistical bias appear to be fundamental properties of the human auditory system that remain resilient to sensory deprivation.

Poster #3.8: Multisensory arrival-time estimation of accelerating vehicles: spectral vehicle sound cues drive the audiovisual benefit

Oberfeld Daniel (1), Huisman Thirsa (1)

1 - Johannes Gutenberg University (Germany)

When pedestrians judge the arrival time of an approaching vehicle (time-to-collision, TTC) to decide whether crossing the road before the vehicle arrives is safe, perception is inherently multisensory. Beyond optic flow, the vehicle's dynamic sound field provides multiple motion cues. The literature consistently shows that visual-only TTC estimates neglect acceleration, indicating estimation based only on first-order motion information, which results in TTC overestimations for accelerating vehicles. Recent work shows that adding the sound of an accelerating combustion-engine vehicle significantly improves TTC estimation accuracy. Here, we investigated which sound features drive this multisensory benefit, using high-fidelity audiovisual simulations of an approaching vehicle, based on audio recordings from a combustion engine car. During acceleration, the increase in engine rotational speed causes an increase in sound power as well as spectral changes. Using audio processing, we selectively removed acceleration-related envelope cues (increase in sound power), spectral cues, or both. As expected, visual-only judgments showed a first-order pattern of overestimated TTCs for accelerating vehicles. When the original sound of an accelerating vehicle was added, the mean estimated TTCs were significantly closer to the veridical values, compatible with previous work. This audiovisual benefit was significantly smaller when the spectral cues or envelope cues to acceleration were removed, with spectral cues having the stronger effect. The pattern of effects was consistent with participants' magnitude estimates of the acceleration strength signaled by the original and processed vehicle sounds. The perceived acceleration was considerably stronger when spectral acceleration cues were available, whereas envelope cues had a weaker effect.

Poster #3.9: The role of visual experience in shaping serial dependence in auditory space

Tonelli Alessia (1) (2), Esposito Davide (1), Calafatello Gloria (1), Gori Monica (1)

1 - Unit for Visually Impaired People (U-VIP), Fondazione Istituto Italiano di Tecnologia (Italy)
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Serial dependence (SD) reflects the tendency of perceptual estimates to be biased toward recently encountered stimuli, promoting perceptual stability over time. Although this phenomenon has been widely documented in vision, far less is known about its mechanisms in audition and whether its emergence depends on visual experience. Investigating SD in individuals with different visual histories offers a valuable opportunity to determine whether cross-trial integration relies on modality-specific mechanisms or on developmentally calibrated processes. We examined auditory spatial localization in early blind (n = 11), late blind (n = 12), and sighted controls (n = 14). Participants performed the task in both the horizontal and vertical planes, allowing us to assess whether SD operates similarly across spatial dimensions and visual experience profiles. The results revealed a reliable attractive SD effect across groups, with no overall main effect of spatial plane. However, a critical interaction emerged for early blind participants, indicating a differential modulation of SD across planes. Specifically, sighted and late blind individuals showed robust SD in both horizontal and vertical localization, whereas early blind participants exhibited a reduced effect on the vertical plane. Furthermore, early blind participants differed significantly from sighted controls specifically in vertical localization. These findings suggest that early visual experience contributes to shaping temporal integration mechanisms in auditory spatial processing, particularly along the vertical dimension. More broadly, the results raise the possibility that SD is not entirely modality- independent but may be partially scaffolded by early

multisensory calibration processes that influence how perceptual systems integrate information over time.

Poster #3.10: Investigating visual and haptic spatial pattern discrimination across age

O'Dowd Alan (1), Newell Fiona (1)

1 - Trinity College Dublin (Ireland)

A decline in sensory acuity typically accompanies healthy ageing. Despite this, older adults often perform as well as younger adults in visual and haptic shape recognition and discrimination tasks. However, age-related deficits have been reported in haptic two- dimensional (2D) shape recognition, possibly due to age-related cognitive factors. Here, we investigated 2D shape pattern discrimination in younger (20–35 years) and older (60– 80 years) adults and examined whether performance was associated with sensory acuity and/or cognitive function. Participants completed a standard XAB matching task involving asymmetric shape patterns. Each pattern consisted of a unique sequence of 16 raised, bumpy Lego bricks arranged on a grid within a smooth tile background. Spatial complexity was manipulated by gradually and systematically spreading the bricks across the grid while maintaining continuous shapes. Shape pattern discrimination was assessed in visual-only and haptic-only conditions across varying levels of difficulty. Exploration was temporally and spatially constrained and serial across both modalities. Overall, visual and haptic shape pattern discrimination were positively correlated. Visual discrimination accuracy was high and comparable across age groups across difficulty levels. In contrast, age differences emerged in the haptic condition, where overall accuracy was lower: older adults showed less improvement in performance from difficult to easy conditions than younger adults. This age difference remained, though attenuated, after adjusting for sensory and cognitive function. These findings suggest that shape pattern discrimination is more susceptible to age- related decline in the haptic modality, possibly because the spatiotemporal nature of haptic exploration is more perceptually challenging with age.

Poster #3.11: Additive combination of correspondence biases during motion occlusion: crossmodal and within-modality evidence

Hendler Flavia (1), Gabay Shai (1)

1 - IIPDM, Haifa Universtiy (Israel)

Crossmodal correspondences are systematic associations between features from different senses that bias perception, yet research has focused on conditions where both modalities provide concurrent input. Whether correspondences persist without continuous sensory input, and how multiple biases combine, remains underexplored. We address both questions using motion occlusion, where objects disappear behind barriers and speed judgments depend on velocity estimates formed without visual input, while auditory stimulation continues. Participants judged when an occluded object reached a target; keypress position indexed perceived speed. Across three studies, auditory pitch and visual spatial frequency independently biased perceived speed during occlusion, with high pitch and high spatial frequency both increasing perceived speed. When combined with one another (N=26) or with object size (N=37), features combined additively with no interaction. At 24°/s—beyond previously tested ranges—the size–speed correspondence reversed direction, with larger objects perceived as faster. The reversal suggests that correspondence direction depends on the processing regime engaged at a given speed. Two additional studies extend existing research to new speeds and to within-modality combinations. A size-only study (N=30) maps the size–speed correspondence across four

speeds (2.5–24°/s) to characterize the reversal systematically. A size × spatial frequency study (N=30)—features coupled in V1 through receptive field size and spatial frequency tuning—tests whether within-modality features interact or combine additively as observed for crossmodal pairs. Non-interactive combination would indicate that correspondence biases operate through independent channels regardless of whether features share early cortical processing. Interactive combination would suggest that modality separation itself shapes how correspondences combine.

Poster #3.12: Can haptic cues help the localization of a 3D moving audio target in virtual reality?

Caroglio Emanuele (1), Vannucci Fabio (1), Zanchi Silvia (1), Gori Monica (1)

1 - Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia (Italy)

In everyday life, we perceive static or moving objects trough different sensory modalities, primarily vision and audition. Although auditory cues generally provide less precise spatial information than visual cues, they become particularly important when visual input is sound sources, with limited attention to moving auditory stimuli. In this pilot study, we used Virtual Reality (VR) to assess how accurately and quickly participants can localize a moving 3D auditory target, and whether adding haptic (vibrotactile) cues improve performance compared to auditory cues alone. Seven healthy participants (age mean y.o. (SD): 29.4 (3.4), F = 5) were tested using a Meta Quest Pro headset, which enabled the delivery of spatialized audio and vibrotactile cues via controller. Participants kept their eyes closed and were instructed to hit a virtual moving auditory target by aligning their head with it. The experiment consisted of 48 trials divided into two conditions: auditory-only (A) and auditory with vibrotactile cues (AT). In the AT condition, vibrotactile cues were delivered as vibrations via the controllers, with vibration frequency increasing as the participant's head approached the target. Preliminary analyses showed that numerically localization error and variability were reduced in the AT condition; generally, participants tended to consistently anticipate the target. Response time did not vary across conditions. Similar to previous literature about static auditory and tactile cues, these findings suggest that spatial perception for auditory moving targets may benefit from spatially congruent tactile signals. This work of the MELD (Multisensory Environments to study Longitudinal Development) is supported by a generous unrestricted gift from Reality Labs Research, a division of Meta.

Poster #3.13: Opposite errors in visual vs haptic updating

*Nadeem Ahmed (1), Harris Laurence (1)**

1 - York University, Toronto (Canada)
**speaker*

When undergoing self-motion, one must continuously update an internal representation of the locations of surrounding objects to interact effectively with them. If self-motion were to be misestimated, their updated locations would be systematically biased and less reliable. Visually simulated self-motion evokes visual updating errors in the direction of travel (Kim & Harris PLOS ONE 2024). Are similar haptic spatial updating errors found? Blindfolded participants haptically searched a tabletop to retrieve a motion-tracked object. They then either remained stationary for 5 s or translated themselves physically leftward, rightward, forwards or backwards (1 step ≈30 cm; 2 steps ≈60 cm). They then replaced the object at what they thought was its original location. Bias was assessed as the error along the motion axis and precision was within-participant variability across repeated

placements. Active translation produced systematic biases opposite the direction of travel. Lateral self- motion (rightward or leftward) yielded leftward and rightward biases respectively (opposite to the direction of self-motion). Antero-posterior self-motion (forward or backward) yielded backward and forward biases respectively (again opposite to the direction of motion). Bias magnitude increased with translation distance, from ~5–10 cm after a 30 cm step to ~10– 20 cm after a 60 cm translation. Precision was ~2 cm under stationary baselines but increased under self-motion, reaching ~8 cm at many target locations. These findings indicate that haptic spatial updating during active physical translation overcompensates for self-motion and diverges from reported visual updating patterns.

Poster #3.14: Mapping the invisible: spontaneous spatial representations through haptic exploration

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3 - Institut Universitaire de France (France)

Spatial representations can be constructed through both vision and touch, yet the mechanisms by which the haptic system generates them remain debated. Prior studies inform participants in advance about task requirements, such as object recognition, potentially biasing encoding strategies and promoting visually mediated processing. This raises the question of whether spatial representations can emerge automatically during haptic exploration without explicit task-directed attention. To address this, participants traced an unfamiliar two-dimensional raised-line shape under different sensory and awareness conditions. A Haptic–informed group explored the shape without vision, knowing they would later reproduce it, whereas a Haptic–naïve group explored without prior knowledge of reproduction. Two Visual control groups either traced or observed the visible shape without prior information. An additional control group produced random shapes to estimate baseline reproduction performance in the absence of spatial representations. After reproduction, the Haptic and Visual groups attempted shape recognition among 14 alternatives. Similarity analyses between drawn and original shapes showed that all groups outperformed the random control, indicating formation of spatial representations. Foreknowledge did not improve reproduction accuracy in the haptic condition, though visual conditions exceeded purely haptic performance. In the recognition task, prior knowledge enhanced performance, but the Haptic-naïve group also performed above chance. To examine neural correlates of spontaneous encoding, EEG was recorded during haptic exploration in the Haptic-naïve group. Source analysis revealed activation in visual, prefrontal, temporal and parietal regions. These findings suggest that spatial representations can emerge spontaneously during haptic exploration, through cross-modal recruitment of visual, somatosensory and attentional networks.

Crossmodal Interactions & Perceptual Illusions

Poster #3.15: Smelling the target: olfactory-visual interactions in food-related visual search

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Visual search efficiency is typically determined by object features such as color, contrast, and shape. However, everyday search behavior unfolds in multisensory environments. Here, we investigated whether task-irrelevant olfactory cues modulate performance in a demanding visual search task for food items. Participants performed a cued search for a target fruit (lemon, apple, or strawberry) presented among seven fruit distractors, while being orthonasally exposed via a four-channel olfactometer to either a congruent odor (matching the target), an incongruent odor (matching a distractor or unrelated to the displayed fruits), or neutral air (baseline). Both accuracy and response times were systematically influenced by odor–target congruency. Congruent olfactory stimulation enhanced performance and reduced response times relative to incongruent and neutral conditions. Crucially, multisensory congruency effects interacted with individual baseline search efficiency: low-performing participants showed the strongest facilitation from congruent odors, whereas high-performing individuals were selectively impaired by incongruent odor–target pairings. A post-experiment odor discrimination task revealed that olfactory discriminative ability correlated with both the magnitude and the direction of the congruency effect, suggesting that crossmodal influences depend on how effectively the olfactory signal is processed. These findings demonstrate that even spatially non-informative odors can bias visual search for semantically matching objects. Rather than acting as a simple additive cue, olfactory input appears to modulate signal-to-noise dynamics in a performance-dependent manner. Overall, this work highlights the functional contribution of olfaction to spatial cognition and suggests that multisensory congruency may shape decision-making in ecologically relevant contexts such as food selection.

Poster #3.16: Contextual and affective dimensions of visual-olfactory congruency: a preregistered design for urban environments

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Crossmodal congruency is central to multisensory research, yet its operationalization remains inconsistent, particularly in ecologically complex settings such as urban greenspaces, where visual and olfactory signals jointly shape environmental perception and behavior. Existing work typically treats congruency as unitary, conflating whether an odor fits the situational context of a scene (source plausibility, expectedness) with whether odor and scene elicit matching affective responses (aligned valence and arousal). This conflation limits both mechanistic explanation and translational design guidance. Drawing on predictive processing and Bayesian causal inference, we propose that visual-olfactory congruency in environmental contexts comprises two separable dimensions: contextual congruency (the degree to which an odor is perceived as a plausible, expected emanation of the visual scene) and affective congruency (the degree to which odor and scene evoke aligned emotional responses). We describe a preregistered within-subjects 2 (contextual congruency: high vs. low) × 2 (affective congruency: high vs. low) laboratory experiment using urban greenspace visual-olfactory stimulus pairs. Dependent measures span environmental perception (coherence, comfort, perceived safety), emotional and stress responses (self-reported valence/arousal; HRV, electrodermal activity), and behavior (dwell willingness, revisit intention). Sensory processing sensitivity is included as a continuous moderator. We predict that: (H1) congruent conditions will enhance coherence and comfort while attenuating stress; (H2) contextual incongruency will primarily impair perceived coherence, whereas affective incongruency will primarily drive negative affect and avoidance; (H3)

higher sensory processing sensitivity will amplify responses to incongruent conditions. This design aims to decompose congruency into functionally distinct dimensions and inform inclusive multisensory urban design.

Poster #3.17: Audiovisual asynchrony modulates the pleasantness of aversive sounds

Mahzouni Ghazaleh (1), Davidenko Nicolas (1)

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Our previous work found that the unpleasantness of certain aversive sounds (e.g., chewing) can be reduced by synchronizing those sounds with a positive alternative visual source (PAVS, e.g., video of tearing a piece of paper; Samermit et al., 2022). This benefit manifests in both healthy controls and individuals with misophonia, a condition characterized by reduced tolerance to repetitive orofacial sounds such as chewing, breathing, etc. (Mahzouni et al., 2024). Our current study aimed to address whether the precise synchrony between the audio and visual sources in the PAVS and OVS (original video source) stimuli modulates this effect. We asked 77 adults (48 controls and 29 with misophonia) to rate the pleasantness of sounds presented either alone or paired with PAVS or OVS videos, with audio and visual tracks either synchronized or desynchronized by +500 ms (video-leading) or -500 ms (audio-leading). Compared to sounds alone, synchronized PAVS significantly increased pleasantness ratings, whereas synchronized OVS significantly reduced pleasantness ratings. This PAVS vs. OVS benefit (reflected by higher pleasantness ratings of PAVS-paired sounds) was significantly reduced, but not eliminated, for desynchronized videos. This reduction was driven entirely by increased pleasantness ratings of desynchronized OVS-paired sounds compared to synchronized OVS-paired videos, whereas there was no effect of synchrony on the rated pleasantness of PAVS-paired sounds. These findings highlight the role of both low-level factors (i.e., audiovisual synchrony) and high-level factors (i.e., the belief about a sound's source) in influencing the pleasantness of sounds.

Poster #3.18: Comparisons between types of crossmodal correspondences using speeded classification paradigm and subjective rating

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Humans perceive implicit associations between features and perceptual similarities across sensory modalities, a phenomenon known as crossmodal correspondence. These correspondences have been classified into three types: structural, statistical, and semantic correspondences. These types are assumed to differ in the processing levels at which implicit associations occur. However, these classifications have not yet been systematically compared within a single experimental task. Thus, this study compared the three types of crossmodal correspondence using a speeded classification paradigm for visual features and subjective ratings. In the experiment, participants responded as quickly as possible to indicate which of two types of visual stimuli were presented, separately for contrast and size. In the congruent condition, corresponding auditory stimuli were presented; in the incongruent condition, non-corresponding auditory stimuli were presented simultaneously with the visual stimuli according to the intensity–contrast, pitch– size, and intensity–size correspondences. In the unimodal condition, only visual stimuli were presented. The response time results indicated that the tendency for crossmodal correspondence was partially observed in the intensity–contrast and pitch–size correspondences. On the other hand, a subjective rating task conducted using a visual analogue scale before the speeded classification paradigm clearly showed associations between

sensory features in all types of crossmodal correspondences. Furthermore, in the subjective rating conducted after the speeded classification paradigm, the association for the intensity–contrast correspondence increased, whereas that for the pitch–size correspondence diminished. These results suggest differences in the magnitude of association among the types of crossmodal correspondences.

Poster #3.19: Alpha phase predicts the flash-lag illusion when the flash is preceded by a sound

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The waxing and waning of alpha oscillations are proposed to reflect rhythmic perceptual sampling of sensory input. However, findings on the relationship between the alpha phase and perception are inconsistent. Furthermore, studies comparing alpha phase effects on unisensory and multisensory processing are sparse. In this EEG study (N = 21) we tested whether the visual alpha phase predicts perception in the flash-lag illusion when it is presented with or without a preceding sound. A moving bar was presented alongside a central flash, which often led participants to perceive the bar as being farther along its trajectory than its actual position. The flash was presented either 51 or 16 ms before the bar reached the center of the screen. In multisensory conditions, an additional sound was presented 100 ms before the flash. Higher illusion rates were found for the 16 ms compared to the 51 ms condition. Additionally, an interaction was observed between flash onset and unisensory vs. multisensory conditions. EEG data analysis examined the effects of the prestimulus alpha phase in the 51 ms conditions, enabling a comparison of illusory and non-illusory trials using the Phase Bifurcation Index (PBI). Differences in the alpha phase were found between illusory and non-illusory trials, particularly in the multisensory condition. There were also significant differences in PBIs between conditions. These results suggest that the alpha phase influences the flash-lag illusion when an additional sound is presented, which could be related to a crossmodally resetting of the alpha phase by the sound.

Poster #3.20: Frequency-specific modulation of the stream-bounce illusion via fronto-parietal Tacs

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Multisensory processing across distributed cortical networks plays a key role in resolving perceptual ambiguity. The stream-bounce illusion offers a robust paradigm for investigating this multisensory

disambiguation, as a temporally proximate sound reliably increases the likelihood of perceiving two moving objects as bouncing rather than streaming. The right posterior parietal cortex has been consistently implicated in audiovisual processing in this context, highlighting its role in determining which signals from different senses are integrated. Previous evidence suggests that large-scale cortical communication is mediated by frequency-specific oscillatory synchronization. In particular, beta-band synchronization (~20 Hz) within a fronto-parieto-occipital network has been shown to predict perceptual outcomes in audiovisual ambiguity. To test the causal role of this mechanism, we applied frequency-specific transcranial alternating current stimulation (tACS) over the fronto-parietal network (F4-P4 electrode sites) while participants performed an audiovisual stream-bounce task. Twelve participants completed three counterbalanced stimulation sessions (5 Hz, 19 Hz, and sham) at 1.5 mA, administered on separate days. Aligned-rank transform ANOVA revealed a significant main effect of stimulation frequency on bounce percepts (F, |, = 59.56, p <.001, '72,, =.01) with beta-band stimulation (19 Hz) selectively increasing bounce responses relative to both theta control (5 Hz) and sham stimulation. These results provide causal evidence for the involvement of beta-band dynamics within fronto-parietal networks in shaping perceptual organization, and demonstrate that tACS can modulate perceptual outcomes during multisensory processing in a frequency-specific manner.

Poster #3.21: Crossmodal postdiction in multisensory integration

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Information from different sensory modalities is integrated in a temporal window of multisensory processing that can last several hundred milliseconds. Within this window, the processing of a stimulus is influenced not only by preceding and concurrent input, but also by input following a stimulus. A previous study using a beep-flash pair showed that auditory or visual stimuli presented shortly after a stimulus can retroactively influence the perception of the first stimulus, resulting in an illusory or invisible flash (Stiles et al., 2018; PloS One 13:e0204217). A single beep presented between two flash-beep pairs can induce an illusory flash, whereas a single flash presented between two flash-beep pairs can be perceptually suppressed. In this behavioral study (N = 32), we used a Bayesian Causal Inference (BCI) framework to investigate the mechanisms underlying the two multisensory postdictive illusions. We replicated both illusions, found that asynchronous stimuli that fall outside the temporal integration window reduce the illusions, and that the causal inference framework can largely explain cross-modal postdiction better than competing forced- fusion and forced-segregation models. In addition, we present EEG data that offer insight into the neural mechanisms of the observed multisensory postdictive illusions.

Poster #3.22: The sound of smell: cross-modal correspondences between timbre and odor

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Several hypotheses have been proposed to explain sound–smell associations [Deroy, Crisinel, & Spence, 2013]: an amodal hypothesis based on shared sensory dimensions, an indirect hypothesis mediated by emotional similarities, and a transitivity hypothesis in which correspondences arise through an intermediate relation. Even though sound and smell share a metaphorical vocabulary (e.g., notes, accords), empirical support for crossmodal correspondences remains limited. This study

investigates whether affects mediate crossmodal relationships between timbre and olfactory ingredients. For this purpose, we conducted three experiments. In Experiments 1 and 2, 61 and 60 participants, respectively, sorted 80 timbres and 24 odors using eight affective labels: Apathy, Depression, Happiness, Irritation, Relaxation, Sensuality, Stimulation, and Stress. Some affects (particularly Stimulation, Stress, and Irritation) were solidly induced across both modalities. Experiment 3 tested direct crossmodal matching: 62 participants matched five groups of timbres to five groups of odors selected based on Experiments 1 and 2. This comparison between direct crossmodal judgments and indirect affect-based associations revealed that several affects (e.g., Stimulation, Relaxation) reliably predicted crossmodal matches, while others (e.g., Apathy, Happiness) showed more ambiguous relationships. These findings support the idea that affective responses serve as an implicit bridge between sound and smell. Finally, acoustic analyses examined temporal, spectral, and spectrotemporal features to model how specific timbral properties induce affects. This approach aims to identify the acoustic dimensions that underlie the affective profiles associated with different olfactory ingredients, thereby determining which sound features can systematically predict sound–smell correspondences. Internal

Poster #3.23: Neural correlates of proprioceptive illusion perception

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Behavioral differences between proprioceptive illusion perceivers (IP) and non-perceivers (NP) Although electroencephalography (EEG) has been used to demonstrate neural distinctions associated with proprioceptive illusion perception, these differences remain underexplored. The present study combined EEG with illusion-inducing muscle vibrations to examine behavioral and neural differences—specifically power spectral density (PSD) and event-related potentials (ERPs)—across group (IP vs NP) and illusion-inducing conditions (manipulating visual input and vibration location). Behavioral and neural measures were compared using electrodes located bilaterally over the sensorimotor area, visual-proprioceptive association area, and supramarginal gyrus. Behaviorally, the addition of visual input was as detrimental to illusion perception as altering the location of the vibration stimulus. Neurally, IP exhibited reduced PSD values relative to NP across regions of interest, and PSD was lower in conditions with visual input compared to those without. ERP amplitudes were reduced in the visual-input condition bilaterally within the visual–proprioceptive association areas, but not in other regions of interest. Overall, the more robust PSD effects relative to limited ERP findings suggest that the observed differences reflect broader, sustained neural dynamics rather than temporally specific responses. Collectively, these results demonstrate visual dominance over proprioception during a proprioceptive illusion at both behavioral and neural levels.

Poster #3.24: How wearing a glove affects perceived weight: a lower force precision increases the size-weight illusion

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How heavy an object feels obviously depends on haptic information about the forces required to lift an object. But it is also influenced by visual and haptic information about less relevant properties, such as the object's size (the size–weight illusion). We hypothesized that the influence of size information would increase if we made force- related information less precise. We assumed that wearing a glove

would reduce the precision of tactile signals. In two experiments, we examined whether wearing a glove increases the size–weight illusion. Contrary to our expectation, wearing the glove did not systematically affect the precision of judgments of how heavy objects are; the effect differed across participants. Crucially, though, the results provide strong support for the hypothesis that a reduced precision of force-related haptic information leads to an increased size–weight illusion. A-C) reported mass and its coefficient of variation (CV) for each of the four blocks, and the overall values for the size-weight illusion with and without a glove. Error bars indicate the standard error of the mean across participants. D) The effect of the glove on the size-weight illusion (i.e., the SWI with glove minus the SWI without glove) plotted as a function of the effect of the glove on the coefficient of variation. Each magenta symbol represents the average value for a single participant. The green symbol represents the overall mean (error bars 95% confidence interval). The green ellipse indicates 95% of the distribution.

Poster #3.25: Neuroplastic effects of combined action observation and kinesthetic illusion are preserved in older adults

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Human responses to multisensory stimuli vary across the lifespan depending on the type of stimulation and the experimental paradigm used, with the integration of visual and proprioceptive inputs appearing to be relatively preserved in aging. An age-dependent effect was observed also in the possibility to develop associative plasticity following protocols combining central and peripheral stimuli. Repeated exposure to congruent stimuli from different sensory modalities has been shown to promote cortical plasticity. In particular, the combination of action observation (AO) and proprioceptive stimulation inducing a kinesthetic illusion (KI) has been reported to produce a long-lasting increase in primary motor cortex (M1) excitability in young adults. However, evidence on the possibility of exploiting the AO–KI paradigm to induce M1 plasticity in older adults is currently lacking. Therefore, the present study aimed to evaluate the effectiveness of AO–KI in modulating M1 excitability in this population. M1 excitability was assessed in eighteen healthy older adults before AO-KI administration, immediately afterward, and at 30 and 60 minutes post-intervention, using transcranial magnetic stimulation to construct recruitment curves (RCs). Results revealed a significant increase in both the slope and the area of the RCs immediately after AO-KI and persisting up to 60 minutes. These findings suggest that the repeated exposure to multisensory stimuli occurring during AO-KI favored the development of M1 plasticity in older adults, thus proposing AO- KI as a promising approach to promote cortical plasticity and learning or to counteract maladaptive plasticity.

Poster #3.26: High frequency and high amplitude neck muscle vibration induces an illusory percept of head rotation

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Self-motion perception and spatial navigation rely on vestibular, visual, and proprioceptive sensory signals, but the contribution of the proprioceptive system has been hardly investigated. Neck muscle vibration (NMV) can induce proprioceptive sensations of the muscle spindles without actual movements. NMW can alter the perceived body orientation (e.g., subjective straight-ahead) or

locomotion (e.g., gait trajectory). However, previous reports remained inconclusive about which vibration characteristics (e.g., frequency, intensity) are necessary to induce this effect. We developed a new bilateral neck muscle vibrator that can be operated with varying vibration frequencies and amplitudes. Healthy volunteers repeatedly were stimulated on either the left or right dorsal neck muscle (splenius capitis) for ten seconds with frequencies varying from 20 to 150 Hz and with either a low or a high vibration amplitude. On each trial, participants indicated whether they perceived an illusory head position change along yaw, pitch or roll axes on a 7-point scale. Our results showed that neck muscle vibration induced a significant illusory head rotation primarily along the yaw axis towards the side contralateral of vibration. This head position shift was most prominent for high vibration frequencies but absent for low vibration frequencies. Moreover, head position shifts were substantially stronger for high amplitudes than for low amplitudes. These findings are consistent with previous reports and further clarify that a minimum frequency and intensity is required to obtain proprioceptive sensations by NMV. Ongoing research will show how NMV interacts with vestibular and visual cues of self-motion perception and spatial navigation. Funding: This study was supported by the Deutsche Forschungsgemeinschaft (DFG) - Project numbers BE 4536/7-2, GR 988/25-2.

Poster #3.27: When what we felt shapes what we see: cross-modal serial dependence in visuo-haptic integration

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Our perception does not solely depend on current sensory information, but is also influenced by the immediately preceding experience, a phenomenon known as serial dependence (SD). To date, SD has been studied mainly within modalities, with only limited evidence questioning its cross-modal nature. Here, we challenged this matter by investigating whether SD can be elicited in visuo-haptic interactions, comparing its magnitude when the preceding sensory experience comes from the same or a different modality. Using the Microsoft HoloLens 2 mixed-reality headset, we designed an experimental paradigm that allowed us to selectively isolate visual perception from haptic perception while keeping the stimulus's spatial position and bodily context constant. We performed four size discrimination tasks on adult participants, in which a visual or tactile reference sphere (80 mm) was compared with a test one (74-86 mm) in the same modality, preceded by a larger or smaller inducer sphere (77/83 mm) presented either in the same or a different modality (two unimodal and two cross-modal conditions). Our results revealed robust SD effects in both unimodal conditions. Importantly, we also observed significant SD effects in cross-modal conditions, when the inducer belonged to a different sensory modality than that of the test and the reference. These findings suggest partial integration of information between vision and touch, indicating that SD can operate at the cross-sensory level. Overall, our results indicate that SD also operates between different sensory modalities, providing new insight into the mechanisms underlying perceptual stability over time.

Poster #3.28: Trigeminal (capsaicin) stimulation enhances saltiness perception: evidence for cross-modal integration

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TRPV1-related mechanisms contribute to responses to concentrated salt. In humans, sensory studies suggest that capsaicin can enhance the perception of saltiness. However, it remains unclear whether this enhancement reflects halo-dumping, a rating tendency in which unrated spiciness is incorporated into saltiness judgments. It is also important to determine whether this enhancement varies across salt concentrations. We conducted a psychophysical experiment to address these issues. Thirty-six adults evaluated NaCl solutions in a 2 × 2 within-participant design with NaCl concentration (100 vs. 200 mM) and capsaicin addition (0 vs. 0.35 μM) as factors. In each trial, participants rated both saltiness and spiciness intensity to minimize halo-dumping. Saltiness ratings were higher when capsaicin was added, with no interaction between NaCl concentration and capsaicin addition. This indicates that capsaicin-induced increase in saltiness perception remains robust under conditions designed to minimize halo-dumping. In contrast, the capsaicin- related increase in perceived spiciness depended on NaCl concentration: It was obvious at 100 mM NaCl but weakened at 200 mM NaCl. This suggests that high salt concentrations themselves may activate trigeminal responses sufficiently to reduce additional effects of capsaicin on spiciness. These findings indicate that a strong perception of saltiness can reflect cross-modal integration of both gustatory and trigeminal inputs. Each graph shows the mean ratings (bars) and standard errors (error bars) for saltiness intensity and spiciness intensity. Gray bars indicate the capsaicin-added condition and white bars indicate the no-capsaicin condition.

Multisensory Integration & Memory, Cognition and Decision-Making

Poster #3.29: Flexible multisensory category representations across vision and touch

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Understanding whether category knowledge acquired in one sensory modality generalises across modalities, and how flexibly such knowledge can be updated, is central to multisensory cognition. Although object recognition engages partially overlapping neural systems in vision and touch, it remains unclear how learned category structure transfers between modalities and how these representations reorganise when category boundaries change. Using a two-day behavioural and fMRI paradigm, we investigate cross-modal category learning with novel 3D objects. Participants learn to categorise objects along one perceptual dimension (i.e., shape or elongation) in either vision or haptics. On the second day, they perform the learned task, transfer the rule to the untrained modality, and subsequently relearn the objects following a shift in category boundary. Preliminary behavioural findings suggest robust category acquisition in both modalities, with participants reaching criterion performance (>80%) during training. Accuracy patterns suggest that category knowledge can generalise across modalities, though transfer costs vary across conditions. When the category boundary changes, performance initially decreases but improves with retraining, consistent with flexible updating, rather than simple stimulus–response memorisation. Ongoing neuroimaging analyses using multivariate pattern and representational similarity approaches will examine how neural representational geometry changes across learning, cross-modal transfer, and boundary restructuring. We predict that early sensory cortices will reflect modality-specific perceptual similarity, whereas higher-level ventral temporal and fronto-parietal regions will encode modality-independent category structure and show representational reorganisation following boundary change. This work aims to elucidate the acquisition, cross-modal generalisation, and flexible updating of multisensory category representations in the human brain.

Poster #3.30: Sensory memory, aging, and technology use in the workplace: insights from the BRIC 30 ActiveAgeIT project

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Multisensory memory supports everyday interactions with digital environments by integrating information across multiple modalities. However, little is known about how workplace exposure to technology relates to sensory memory performance across adulthood. Within the BRIC 30 ActiveAgeIT project and in the framework of the Technologies for Healthy Living IIT Flagship we investigated visuo-haptic and auditory spatial memory in workers with different levels of technology use. Fifty-three participants were categorized into high-technology-use and low-technology-use groups based on self- reported workplace engagement. Participants completed two memory paradigms: the iCube task, in which they rotated a sensorized cube to encode and recall its faces, assessing visuo-haptic memory, and AudioCorsi, an auditory variant of the Corsi block task measuring sequence memory. Participants also completed questionnaires assessing cognitive failures, technostress, and technology attitudes. In the iCube task, accuracy was significantly higher in the visuo-haptic condition compared to the haptic-only condition, indicating that visual information substantially facilitated spatial memory encoding during exploration. In contrast, in the Corsi task age and technology exposure interacted in forward spatial span, suggesting that older participants with lower technology use may rely on more effortful memory strategies. Visuo-haptic memory performance did not correlate with auditory spatial span, suggesting that the two paradigms capture partially distinct memory components. Subjective evaluations of technology differed markedly: high-technology-use participants reported greater empowerment but also higher perceived risks and technostress. Overall, sensory modality and age played a stronger role than technology exposure in shaping memory performance, while technology use primarily influenced attitudes toward digital environments.

Poster #3.31: Revisiting working memory as a modality-specific storage system

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Working memory (WM) is commonly described as a modality-specific storage system, as proposed by influential theories such as the multicomponent model and the sensory recruitment hypothesis. These frameworks have encouraged the view that visual and auditory information are maintained in separate sensory systems. Nuancing this strict separation, however, recent work has shown that observers can strategically transform WM representations to match recall modality. Here, we go further by asking whether certain types of information are inherently better suited for one modality than the other. Specifically, we hypothesized that auditory storage is optimized for temporal information, whereas visual storage is optimized for spatial information, irrespective of encoding modality. Across two experiments (N=72), participants performed either a temporal reproduction task, memorizing sequences of five targets with varying durations and inter-stimulus- intervals, or a spatial reproduction task, memorizing five locations. Targets were presented auditorily (white noise) or visually (white circles), followed by auditory (repeating word), visual (following dots by eye-movement), or no

interference. Participants then reproduced the temporal sequence or spatial pattern via mouse clicks, excluding response-modality confounds. A clear interaction emerged: temporal sequences were reproduced more accurately when encoded auditorily, whereas spatial patterns were reproduced more accurately when encoded visually. Although both interference tasks reduced performance relative to baseline, neither modality-specific nor functionality-specific interference selectively impaired performance. These findings suggests modality-specific encoding advantages that depend on information type (temporal vs spatial). During maintenance, however, memoranda were not clearly segregated by modality or functionality, which could reflect the use of a non-sensory representational format.

Poster #3.32: Mental imagery alters reactions to aversive sounds

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We previously showed that plausible alternative video sources (PAVS; e.g. video of someone tearing paper) reduce the unpleasantness of aversive and misophonic trigger sounds (e.g. the sound of crunchy chewing; Mahzouni et al., 2024). We posited that these effects rely on the observer's belief about the source of a sound and may therefore be elicited using mental imagery alone. Participants (N=36) completed two experimental blocks in which they heard and rated 14 misophonic sounds presented twice within each block. In the first block, each sound was paired with both its original video source (OVS) and with a PAVS source. Participants first judged the plausibility of each source producing each sound and then the distress, disgust, and bodily sensations they felt while hearing the sound. In the second block, participants heard the same 14 sounds while instructed to imagine that each sound was produced by an OVS or PAVS source. Participants then rated their success in the imagery task and their distress, disgust, and bodily sensations produced by each sound. In Block 1, reactions to sounds were substantially modulated by the video source, replicating our previous findings. Critically, in Block 2, simply imagining the source of a sound produced similar (though smaller) modulations in reactions: misophonic trigger sounds were rated as less distressful, less disgusting, and as producing less negative bodily sensations when participants were instructed to imagine it was produced by the PAVS source. We discuss implications of these findings toward the development of imagery-based interventions for misophonia.

Poster #3.33: Exploring cross-modal effects: the interplay between auditory spatial training and visuospatial skills

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Visuospatial and working memory (WM) abilities are crucial for daily tasks and engaging with the external environment. Current evaluations rely heavily on visual span tasks, such as the Corsi Block-Tapping Test (CBTT), in which participants observe a sequence of blocks being tapped or highlighted in a specific irregular pattern and must reproduce the sequence in the same order. Computerized visual CBTT training has improved mental rotation and visuospatial WM in adults and children, even after one session. Despite having valuable insights into spatial mechanisms in the visual modality, the exploration of cross-modal aspects of WM is limited. Therefore, this study investigates whether a training session with our acoustic version of the Corsi Block Tapping Task (CBTT), named Audio-Corsi, could impact mental rotation abilities in the visual domain. Fifty-four young adults (aged 25-35 years)

participated, divided into a control group and an experimental group, matched for age and biological sex. Performance was evaluated in terms of reaction times (RTs) for correct trials on a computer-based Mental Rotation Task, in which participants judged whether pairs of 3D figures were identical or mirrored versions after mentally rotating them, both before and after the intervention/resting: the control group underwent 20 minutes of rest, while the experimental group completed training with the Audio-Corsi. The results reveal a significant difference in the reduction of RTs between the two groups. This suggests that visuospatial skills can be trained and potentially enhanced through spatial memory trainings in alternative sensory modalities, such as audition. This work of the MELD (Multisensory Environments to study Longitudinal Development) was supported by a generous unrestricted gift from Reality Labs Research, a division of Meta.

Poster #3.34: Lower-limb movement fingerprints under sensory and cognitive stress

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Stroke often produces co-occurring motor and sensory deficits in the lower limb, yet standard clinical assessments struggle to isolate how cognitive or sensory factors shape movement execution. The lower-limb square task, in which seated participants trace the perimeter of a floor- mounted square, is a common tool for assessing lower-limb motor disorder, but whether performance is sensitive to concurrent cognitive load or sensory disruption remains unknown. To address this question, healthy participants performed the square task under five conditions: eyes open (EO), eyes closed (EC), paresthesia (PA), working memory (WM), and mental arithmetic (MA). Initial univariate analysis of velocity, root-mean-square error, and dwell time each revealed that both cognitive and sensory disruptions resulted in worse performance (e.g., higher error and reduced velocity) compared to the EO condition, yet no single variable captured the full behavioural pattern. We therefore adopted a multivariate approach, constructing a composite movement profile for each participant and condition. This analysis revealed a significant overall condition effect. EC and MA produced the largest deviations from the EO baseline, paresthesia was intermediate, and WM showed the smallest deviation. Critically, conditions differed not only in the magnitude of behavioural change, but also in its structure: conditions with comparable overall disruption remained distinguishable by their pattern of velocity-, accuracy-, and dwell- related behaviour. These results demonstrate that altered sensory and cognitive states generate distinct multidimensional motor signatures rather than nonspecific global impairments and support the square task as a sensitive instrument for characterizing these differences.

Poster #3.35: Embodied transparency as a mechanism for metacognition about self and others

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Metacognitive processes are mechanisms through which individuals monitor and regulate their own cognitive performance. However, during perception, internal states such as uncertainty and effort are often externally manifested through bodily and vocal signals. Embodied signals, as emerged from empirical findings from our lab, are associated with internal states of confidence and effort and can influence social behavior. In this work, I will introduce the notion of embodied transparency, referring to the functional role that embodied expressions may play in both self- and other-directed metacognition, and present a theoretical renewed framework with the aim of generating testable

predictions regarding its mechanisms, boundary conditions, and developmental dynamics. This framework is built on dual-system accounts of metacognition proposed by Shea et al. in 2014 and articulates embodied transparency at two interconnected levels. At the individual level, bodily and vocal signals may provide feedback that contributes to the monitoring and updating of metacognitive representations of one's own perceptual experience. This feedback loop suggests that expression may not merely be an output of internal states, but also a source of information that re-enters the cognitive system and shapes confidence judgments and performance evaluation. At the interpersonal level, others embodied signals may serve as inputs for constructing representations of their metacognitive states, thereby supporting perspective-taking, and may also influence the reshaping of one's own metacognitive representations. This theoretical framework addresses the complex processes of perceptual metacognition by extending current models to incorporate bodily signals, both of the self and others, into the weighting of metacognitive representations.

Poster #3.36: Confidence judgments from integrated multisensory percepts

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Our senses rarely operate in isolation, as building coherent representations of the external world requires integrating information across modalities. Yet, little is known about how confidence emerges from multisensory percepts: does the brain rely on individual sensory cues to generate confidence, or are confidence judgments inevitably tied to the outcome of multisensory integration? To address this question, we designed temporal bisection tasks spanning visual, auditory, and audiovisual modalities. Participants judged whether the second stimulus (S2) in a sequence of three occurred closer in time to the first (S1) or the third (S3), then compared pairs of perceptual judgments to indicate which decision they felt more confident about. In audiovisual trials, the auditory and visual components of S2 were either synchronous or offset by ±100 ms. Crucially, participants were instructed to rely on the visual signal whenever possible. By adapting an established confidence generative model, we then tested three competing hypotheses: participants could (i) compute confidence based solely on the visual cue, (ii) generate confidence independently for each modality and subsequently combine them via weighted summation, or (iii) derive confidence from the integrated multisensory percept. Our results show that participants relied on the optimal audiovisual percept to generate confidence in audiovisual trials, indicating that confidence emerges after multisensory integration. These findings provide new insight into how confidence is computed during perceptual decision-making and constrain the temporal dynamics of metaperceptual processing.

Poster #3.37: Multisensory protocol for executive functions assessment in preschool children with visual impairment

*Gavazzi Giulia (1), Rolando Marika (1), Perasso Giulia (1), Cocchi Elena (1)**

1 - Fondazione David Chiossone, Genova (Italy)
**speaker*

Executive functions (EF) represent a set of higher-order cognitive processes that are essential for self-regulation, learning, and adaptation. In children with visual impairment, the literature suggests increased vulnerability in domains such as planning, inhibitory control, cognitive flexibility, and working memory; however, clinical assessment remains challenging due to the limited accessibility of standardized instruments based on visual stimuli. The present article proposes a protocol for the

assessment of EF in children with visual impairment aged 3–5 years. The protocol includes tasks targeting the main executive domains and adopts multisensory adaptations (tactile and auditory) in order to reduce visual load and enhance residual perceptual channels. The objective is to obtain a more accurate and clinically meaningful functional profile in order to: 1 guide early, individualized interventions oriented toward autonomy and participation, and 2 monitor the effectiveness of rehabilitative intervention. Visual impaired children interactions require greater engagement of sensory integration processes and continuous adaptation of learning strategies. It makes relevant the adoption of rehabilitative models to enhance residual sensory channels to support cognitive and behavioral regulation processes. Early neuropsychomotor training assumes a crucial role, given the brain plasticity that characterizes the first years of life and the sensitive developmental windows, when experience can significantly modulate the functional organization of cognitive systems. The proposed protocol in the pilot study addressed this gap by offering a model of early assessment based on multisensory tasks and functional observation of behavior, capable of capturing not only difficulties but also the child's strengths and compensatory strategies.

POSTER SESSION 4

JUNE 26th | 3:45 pm – 5:00 pm

HALL

Development of Multisensory Experience

Poster #4.1: Nap modulation of cross-sensory audio-tactile skills in visually impaired and sighed infants: an EEG study

Ansaldo Chiara (1) (2), Vitali Helene (1), Campus Claudio (1), De Giorgis Valentina (3), Signorini Sabrina (3), Gori Monica (1)

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2 - DIBRIS, Universitá di Genova (Italy)
3 - IRCCS Fondazione Mondino (Italy)

Vision plays a significant role in the multisensory representation of the body and the external world in early life, as well as in the development of neural networks. A lack of visual experience modifies how sensory signals are weighted and affects the maturation of brain rhythms. Since information encoded during wakefulness is reprocessed during sleep, the absence of one sensory modality affects the neural activity during both states. Moreover, visually impaired (VI) children exhibit an overrepresentation of low-frequency EEG activity and a delayed shift towards alpha rhythms. During sleep, they also present reduced fast-spindle density and power, typically associated with sensorimotor processing. However, the reprocessing of multisensory signals during sleep and the influence of sleep on neural responses in VI and sighted infants remain unexplored. We recorded video-EEG in 25 infants (11 VI, mean age 16 months). We provided audio- tactile hand stimulations during unisensory and multisensory audio-tactile stimulation, before and after a 50-minute nap. EEG data were processed using EEGLAB to compute spectral measures, focusing on the alpha rhythm. Auditory and tactile unisensory stimulations mainly involved temporo-posterior and central regions, respectively, while congruent and incongruent multisensory stimulations mainly involve posterior regions. Pre-post differences were found in both sighted and VI infants. In the post-nap session, it seems that sleep attenuate differences between sighted and VI. Acknowledgment: This work is funded by EU H2020, ERC StG' MySpace, Grant Agreement No. 948349.

Poster #4.2: Elucidating the neurodevelopment of multisensory integration in the common marmoset

Wang James (1), Cook Tyler (1), Gacoin Maëva (1), Cléry Justine (1)

1 - Department of Neurology and Neurosurgery, McGill University (Canada)

Multisensory integration (MSI) is an important cognitive function that is typically disturbed in individuals with Autism Spectrum Disorder (ASD). However, understanding how MSI is disrupted in ASD requires an appropriate and translatable animal-model for properly understanding its development and representation in the brain. The common marmoset (Callithrix jacchus), a small primate with rich social behaviors, a high reproduction rate, and the capability for genetic modification has emerged as a possible candidate for modelling ASD. To investigate MSI in marmoset models of ASD, it is first necessary to understand how this function typically develops in the species, answering

this key question: How are multiple senses encoded and combined by the marmoset brain across their development? We hypothesize that a similar parieto-frontal network seen in humans will activate for MSI in marmosets that is refined with age as well as modulated by valence and an increase in myelin content. To test this, I have collected behavioural data through in-cage touchscreen system with multisensory tasks, and structural and functional (resting state and multisensory task- based) MRI data from 6 (juvenile) to 18-month-old (adult). Preliminary analyses show activations in visual, auditory and somatosensory areas in response to specific unimodal stimulation. Furthermore, when displaying bimodal stimulation (e.g., audiovisual), prefrontal activations appear at 12 but not at 9-month-old, suggesting the progressive reinforcement of MSI mechanisms throughout neurodevelopment. This research is giving insights on the neurodevelopment of primate MSI, and by extension cognition, that could help characterize the development of ASD and other MSI- related neurological disorders in humans.

Poster #4.3: Developmental differences in low-level audiovisual feature learning

Machado Anna (1), Cristaldi Adriano (1), Chang Dr. Catherine (1), Wallace Dr. Mark (1)

1 - Vanderbilt University, Nashville (United States)

Multisensory learning plays a critical role in the development of perception, cognition, and behavior. Understanding how individuals learn to associate low-level features across modalities is essential for assessing developmental changes in multisensory processing. This study explores developmental differences in multisensory feature mapping using an audiovisual associative 2-alternative forced-choice task. Early adolescents (n = 7, ages 10– 13) and adults (n = 13, ages 18–38) learned to associate ten novel visual shapes (irregular polygons varying in angularity and curvature) with ten novel tones (harmonic stacks varying in fundamental frequency). Using a generalized linear mixed model, we analyzed performance across varying difficulty levels, defined by the tonal proximity of presented stimuli, and compared performance between age groups. Increased difficulty significantly reduced the likelihood of correct responses ($\beta = -0.201$, $p < 0.001$). Notably, difficulty had a greater impact on adult performance relative to early adolescents ($\beta = 0.123$, $p < 0.05$), suggesting adults were more sensitive to discriminating spectrally similar auditory features. Although overall performance did not differ significantly between groups ($\beta = -0.385$, $p = 0.195$), these findings suggest that early adolescent learning is more flexible and less sensitive to task demands. This flexibility may reflect a broader perceptual learning filter, enabling children to maintain accuracy as difficulty increases. Conversely, adults appear more susceptible to cognitive load, reflecting the progressive stabilization of multisensory processing systems with age. These results offer insights into how audiovisual associative learning and sensitivity to task difficulty evolve across development. This research was supported by an unrestricted gift from Reality Labs Research, a division of Meta

Poster #4.4: Modulation of non-nutritive sucking and looking time in response to auditory, visual, and multisensory stimulus saliency

Di Gaudio Margherita (1), Zanchi Silvia (1), Vitali Helene (1), Burr David (1), Gori Monica (1)

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Non-nutritive sucking (NNS) is an early behavior generated by brainstem central pattern generators and modulated by sensory and cortical input. It has been previously used as a behavioral index of infants' perceptual and attentional responses to environmental stimulation, particularly in the auditory domain related to language, where changes in sucking patterns are interpreted as evidence of

stimulus detection. However, whether NNS is similarly modulated by visual input and by the combination of auditory and visual signals (i.e., audiovisual stimulation and gain) remains less clearly characterized. The present study explores the potential of NNS as a measure of toddlers' engagement in response to auditory, visual, and audiovisual stimuli differing in saliency. The sample includes 16 typically developing toddlers (M = 21.75 months, SD = 6.38). Participants were presented with three conditions (auditory, visual, audiovisual), each including six 20-second trials divided into high- and low-saliency stimuli. In the visual condition, a grey screen alternated with a square-wave grid; in the auditory condition, white noise alternated with children's music; in the audiovisual condition, stimuli were presented simultaneously in congruent high- or low-saliency combinations. A permutation ANOVA examined the effects of condition and saliency on fixation time, sucking time, and number of sucks; saliency effects in the auditory condition were assessed via t-test. Preliminary analyses revealed a significant effect of saliency on the number of sucks ($p = .012$), with a trend for sucking time ($p = .056$). No differences emerged between visual and audiovisual conditions, nor for fixation time. Although preliminary, these findings suggest that NNS varies as a function of stimulus saliency and may reflect increased engagement in the presence of more salient sensory input, extending previous auditory findings to visual and audiovisual contexts.

Poster #4.5: Neural signature of sensorimotor contingency: an fNIRS protocol for developmental research

Italia Barbara (1), Gambaretti1 Giulia (1), Poles Karol (1), Cadoni Federico (1), Rossi Sebastiano Alice (1), Bulgarelli Chiara (2), Garbarini Francesca (1)

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2 - Centre for Brain and Cognitive Development, Birkbeck, University of London (United Kingdom)

The infant's ability to detect sensorimotor contingency between actions and consequent sensory feedback is fundamental for developing a coherent self- awareness. Although several studies show behaviourally that this capacity exists from birth, the neural mechanism underlying it is largely unexplored. To fill this gap, we designed a neuroimaging protocol to describe this mechanism's emergence during ontogenetic development. Here, we present preliminary data on adults. We used an fNIRS system with 49 channels covering sensorimotor areas. Our protocol included two blocks: a training phase where participants freely interacted with an object eliciting sounds either contingent on their movement (Contingent Block) or randomly delayed (2-4s; Non-Contingent Block). Crucially, to examine potential carry-over effect in neural activity following training , participants underwent an identical test phase across both training conditions, where they passively listened to the same sounds. We analyzed the data using a data-driven, non-parametric clustering approach. This method identifies clusters of channels in which a significant difference between conditions is present, without prespecified regions of interest. We found one large, bilateral cluster over frontocentral and temporoparietal sites, mainly overlapping sensorimotor and supplementary motor areas. Our data demonstrate that this paradigm reliably captures the neural signature of sensorimotor contingency, indeed contingent movement–sound coupling evokes significantly stronger hemodynamic responses than non-contingent feedback. This design allowed us to measure carry-over effects following ecological training, reproducing the real developmental context where such mechanisms emerge. Finally, this study paves the way for infant research on the development of agency and bodily self-awareness.

Poster #4.6: Audiovisual integration in object segregation: perceptual abilities in children

Calafatello Gloria (1) (2), Zanchi Silvia (1), Balzarotti Nicolò (1) (3), Bremner Andrew (4), Gori Monica (1)

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4 - University of Birmingham (United Kingdom)

The mechanisms supporting multisensory spatial abilities are still emerging in childhoodTo examine multisensory integration and segregation of objects in spatial perception, we administered a spatial task to 23 children aged 3–5 years. Two mobile trolleys moved apart along the horizontal plane while presenting visual (V), auditory (A), or audiovisual (AV) stimuli. Perceptual segregation was inferred from gaze shifts between the stimuli, recorded via synchronized videos, and a Python script estimated the inter- trolley distance at that moment. At the group level, Friedman tests revealed no significant differences across sensory conditions, either for mean perceived distance or variability (all $p > .4$ and $p > .5$, respectively), and no AV advantage relative to the Best Cue. Sensory weights estimated using a Maximum Likelihood Estimation (MLE) framework identified a subgroup of children with comparable auditory and visual weights, consistent with a more balanced use of sensory cues. Within this subgroup, statistical comparisons remained non-significant. However, descriptively, children tended to perceive segregation at shorter distances in AV compared to unimodal conditions, with lower variability than the Best Cue. Overall, these findings highlight substantial inter-individual variability, suggesting that multisensory processing is still developing, with some children showing emerging integration strategies while others rely on a single modality.

Poster #4.7: Prenatal origins of multisensory integration: ultrasound evidence from fetal eye tracking

Poles Karol (1), Ferrari Samantha (1), Rossi Sebastiano Alice (1), Pizzorni Valentina (1), Biasotti Maria (1), Nastruzzo Roberta (1), Oberto Manuela (1), Garbarini Francesca (1)

1 - Università degli studi di Torino (Italy)

Converging behavioral and electrophysiological evidence shows that MSI is already present at birth, as demonstrated by eye-fixation paradigms and EEG recordings (Filippetti et al., 2013; Ronga et al., 2021). However, whether and how this ability emerges before birth remains unknown. Building on our previous work (Ronga et al., 2025), in which we recorded fetal eye movements in response to salient visual stimuli, the present study investigated the earliest manifestations of multisensory engagement in utero using an audio-visual protocol. Through 2D ultrasound, we tracked fetal eye-lens movements and head turns as markers of stimulus-driven orienting behavior. Responses of twenty-four fetuses (mean g.a. 34+5 weeks) were coded across three temporal windows (pre-, during-, and post-stimulation) and four stimulation conditions: unimodal colocalized, unimodal not- colocalized, bimodal colocalized, and bimodal not-colocalized. Unimodal trials consisted of two synchronous auditory-only or visual-only stimuli, whereas bimodal trials involved an audio-visual stimulation. In all conditions, stimuli were delivered on the maternal abdomen either on the same side relative to the fetal head (colocalized) or on opposite sides (not- colocalized). Comparisons between unimodal and bimodal trials indexed MSI, while colocalization effects informed about spatial organization of MSI. Preliminary analyses showed stimulus-driven responses mainly occurring during the stimulation phase, with greater eye-lens than head movements (Fig1A). Crucially, fetuses displayed greater ocular responses to bimodal compared to unimodal stimulation (Fig1B), indicating MSI. Greater responses were observed in not-colocalized relative to colocalized conditions (Fig1C), suggesting a primitive

sensitivity to spatial contingency. These findings provide the first evidence that MSI may begin to develop prenatally.

Poster #4.8: The developmental trajectory of audiovisual looming interactions from childhood to adulthood

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3 - School of psychology, Liverpool Hope University (United Kingdom)
**speaker*

Looming stimuli signal approaching objects and are especially salient because they may indicate imminent collision or threat. Despite evidence of early sensitivity to approaching events from infancy, it remains unclear how audiovisual interactions supporting the perception of approaching objects develop across childhood, and whether they are already mature in children or continue to be refined with age. We examined the developmental trajectory of audiovisual looming perception across a wide age range (5.8–31.6 years). Around one hundred participants completed an online visual discrimination task, judging whether a briefly presented disk was approaching (expanding) or receding (contracting). Visual motion cues were made ambiguous to increase uncertainty and enhance the potential contribution of auditory information. On each trial, the visual stimulus was paired with a looming sound, a receding sound, or no sound. Responses were analysed with generalized linear mixed models. Across participants, looming and receding sounds exerted opposite influences on visual judgments: looming sounds increased "approaching" responses relative to the No-sound condition, whereas receding sounds reduced them. Notably, responses also revealed a robust overall approaching bias across conditions, with participants being more likely to report the disk as approaching in all conditions. The Looming vs No-sound difference increased with age. This developmental change was primarily driven by a reduction in baseline approaching bias across development, whereas responses in the looming condition remained comparatively stable. These findings indicate that although an early approaching bias is present in childhood, the relative selectivity of looming-related audiovisual interactions become more pronounced across development.

Multisensory Experience in Social and Built Environments

Poster #4.9: Haptic feedback amplifies corticospinal excitability during object interactions in VR environments

Schubert Ricarda (1), Bufacchi Ilaria (1), Davare Marco (1)

1 - King's College London (United Kingdom)

Virtual reality (VR) is increasingly used in neurorehabilitation, yet most protocols rely solely on vision and lack haptic feedback during interactions with virtual objects. Given the importance of tactile and proprioceptive inputs for sensorimotor control, embedding haptics in VR could enhance motor cortical activity, and thus promote neuroplasticity- driven recovery. Here we tested whether providing haptics during virtual object contact modulates corticospinal excitability (CSE). Participants (n=26) performed right index-finger movements to touch virtual or real objects while experiencing one of four sensory feedback conditions: (1) vision only, (2) vision plus force feedback from a haptic robot (Phantom TouchX), (3) vision plus force feedback plus contact with a real object, and (4) haptic feedback only. A

head-mounted display generated the virtual environment, with visual and physical workspace elements co-located. Single-pulse transcranial magnetic stimulation (TMS) was applied over the left primary motor cortex at point of object contact. Motor-evoked potentials were recorded from the right first dorsal interosseous, and background muscle activity was quantified over the 200ms preceding TMS. CSE differed significantly across conditions ($\chi^2(3)=22.48$, $p<0.001$), with the lowest excitability found when object contact was conveyed only through vision. All conditions containing any form of haptic information produced higher CSE, regardless of whether visual input was present. Background muscle activity did not vary, ruling out muscle activation as the source of CSE changes. These findings demonstrate that haptic feedback is a key modulator of motor cortical activity during VR-based object interaction, highlighting its relevance for designing VR rehabilitation protocols intended to enhance neuroplasticity.

Poster #4.10: Can we feel connected at a distance? Multisensory pathways to social connection through pseudo-haptic touch in VR

Valori Irene (1), Gambaretti Giulia Anilia (1), Desnoyers-Stewart John (2), Stepanova Ekaterina (2), Riecke Bernhard (2), Dumas Guillaume (3) (4), Fairhurst Merle (1)

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2 - iSpace Lab, School of Interactive Arts and Technology, Simon Fraser University (Canada)
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4 - Mila – Québec Artificial Intelligence Institute, Université de Montréal (Canada)

Social touch fosters human connection, intimacy and well-being. Yet, individual differences play a crucial role, with people often perceiving physical contact as threatening. Here we use an immersive Virtual Reality (VR) experience that leverages neuroaesthetics to create safe, positive and transformative social touch experiences without the vulnerability of actual body contact. In the Embodied Telepresent Connection (ETC), dyads embody gender-neutral and anonymous light-particle avatars and interact through pseudo-haptics: visual and auditory cues to proximity and touch designed to create an illusionary feeling of touch without any haptic input (Desnoyers-Stewart et al., 2023). Exploring whether pseudo-haptics facilitate social connection, the present study investigates the subjective, behavioural and neurophysiological correlates of the ETC experience, looking into individual differences and dyadic outcomes of interpersonal synchrony. Forty-two dyads of adult friends were immersed in the ETC with or without pseudohaptics and completed several No-touch (free movement) or Touch trials (move to touch). The results suggest that pseudohaptics improve subjective experience especially among individuals who have less intimate relationships with their co-experiencing partner, as well as those who are generally more sensitive to interoceptive signals. Moreover, pseudohaptic touch modulates physiological activity over time, creating a dynamic interpersonal space in which soothing and playful exchanges unfold. Multilevel analyses of interpersonal synchrony across kinematic, ECG, and fNIRS measures will be discussed. Overall, this study supports the use of sensory substitution for virtual social touch that can foster social connection, particularly for individuals who may feel less connected in real life.

Poster #4.11: Architecture shapes multisensory space representation for social interaction

Vecchiato Giovanni (1) (2), Guerra Frey Giorgia (3) (1), Matromarino Silvia (1), Fraghì Anna Laura (1), Sanchez Federica (4), Ramkumar Ashwanth (4), Avanzini Pietro (1), Bruno Nicola (3), Serino Andrea (5) (6)*

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2 - Università degli Studi eCampus (Italy)
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6 - Centre Hospitalier Universitaire Vaudois (Switzerland)
**speaker*

We rarely process the environment in isolation, yet how physical and social factors interact to shape spatial representations remains unclear. Recent evidence indicates that the dorsal premotor cortex is engaged during both architectural experiences and social processing, suggesting a functional coupling between the two. Here, we used a multimodal stimulation paradigm across behavioral and EEG experiments to test the hypothesis that fronto-parietal networks may be sensitive to both the environment (indoor vs. outdoor) and the position of a virtual avatar (P1:0.90 m vs. P2: 2.50 m) within it. In the first experiment, participants responded to tactile stimuli while a sound was presented at six distances from the body (D1: 5 cm to D6: 300 cm). Reaction time (RT) showed that P1 avatar caused an interference effect, leading to slower RTs, particularly indoors at close distances and outdoors at far ones. P2 avatar, in contrast, enhanced performance in far space. In the second experiment, the paradigm was adapted for EEG recordings using two stimulation distances (near: D2, 60 cm; far: D5, 240 cm). Ongoing analyses examine ERP modulations (N140, P200) time-locked to tactile stimulation and context-dependent oscillatory patterns (e.g., beta band activity). We expect that the stronger the avatar's effect on multisensory integration, the smaller the ERP amplitudes and the lower the oscillatory power. Overall, others' positions critically shape our space representation, and the effect is modulated by the environment. EEG data will provide further insight into how social cues and architectural context jointly modulate the neural dynamics underlying multisensory processing.

Poster #4.12: The study of multisensory social interaction in children

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2 - Institute for Human and Machine Cognition, Pensacola (United States)

Multisensory perception improves spatial orientation in children. Social interactions are associated with interpersonal synchronization, which is maximized in cooperative social contexts, with direct gaze and physical proximity. However, very little is known about interpersonal synchronization in absence of vision and during early interactions with peers. To fill this gap, we asked blindfolded children to pick up objects and drop them into a box. The box have been placed in front of the child either on a table or held by another peer sitting on a chair (not social vs social). The task was performed either using iReach, a device with an anchor as bracelet providing multisensory (audiotactile) stimulation according to its distance with a tag on an external object (the box), or without any device. Children have been randomly assigned to one of these groups (iReach vs none). In a pilot (8 children; 4 female, age range: 6-7 y.o.), using Bayesian 2 x 2 mixed ANOVA, we observed a moderate evidence for higher accuracy in the social than not social condition (mean difference= 0.16; P social> 0 = 0.87) and reduced execution time in the group using iReach than no device (mean difference= -2.50; P iReach< 0 = 0.86). We planned to recruit 50 children from a local primary school to further test these effects, since they might inform research about multisensory perception in social contexts and have clinical and educational implications for children with visual impairments (blindness). This work of the MELD (Multisensory Environments to study Longitudinal Development) was supported by a generous unrestricted gift from Reality Labs Research, a division of Meta.

Poster #4.13: Multisensory communication in music scenarios

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Interpersonal communication is at the basis of many form of social scenarios such as music performance and literature shows it is typically based on visual feedback. In the present set of studies, we investigated the role that visual experience plays in the context of musical interaction. Motion tracking was used to analyze interpersonal communication between two musicians in three different scenarios with the same cellist as soloist accompanied by (1) a sighted pianist, (2) a congenitally blind pianist, and (3) a sighted but blindfolded pianist. This allowed us to disentangle the differential role of total visual feedback (case 1) from total visual deprivation from birth (case 2) and from temporary visual deprivation (case 3). We then analyzed musical interaction both at the level of performers and at the level of audience. At the level of performers, we divided post-processed cleaned motion data into segments to analyze motor and audio synchrony between the performers and expressive phrasing along the excerpt. Specific motor features, e.g. body sway, resulted to be altered in the blind performer and therefore might be not very informative as literature suggests to synchronize playing. At the level of audience, we presented the extracted segments to trained and non-trained participants in three different modalities (audio, video from motion capture, audio+video) and asked them to annotate the level of synchronisation and emotional tuning on a Likert scale. Emotional tuning was significantly different in the three conditions presented (sighted-sighted, sighted-blindfolded, sighted-blind).

Poster #4.14: Physiology based design: a multisensory approach for human- environment interaction

Bitterman Noemi (1)

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Modern life and urbanization have driven a wedge between people and nature and disrupted our complete dependence on the external environment with its diurnal and seasonal variations. However, our abilities to change the environment and control ambiance in a better, faster and more personalized and dynamic manner are intensifying with the introduction of smart technologies, embedded computing, AI, sensing and ICT. Architects and planners have the ability and power to manipulate external environments by sensory modifications, re-shape human-environment relationships reduce stress, improve performance, satisfaction, mood, sleep quality, nutrition and overall wellness. Despite this potential, there remains a lack of rigorous, controlled scientific studies examining multisensory interactions across diverse populations and environmental conditions. The lecture presents three representative projects of multisensory environment design to stimulate collaboration and further research in the field. 1. Multisensory design of pocket gardens in urban spaces with an emphasis on different olfactory and auditory stimuli. The study was conducted in a 3D visualization laboratory on participants under experimental stressful conditions, monitoring physiological, functional and satisfaction parameters. 2. A studio-based project for multisensory environment design to cope with isolation during lockdown (COVID), e.g. a virtual multisensory meal with friends. 3. A project of designing a multi-sensory environment for ALS patients who are disconnected from environment due to motor disfunction. The three projects present diverse approaches, challenges and methodology in

multisensory design. The findings highlight a critical need for controlled multisensory design research, particularly "experiments in the wild," with special attention to elderly populations.

Poster #4.15: Kinematics-informed latent space modelling reveals neural alignment during interpersonal coordination

Koul Atesh (1) (2), Corsini Alessandro (2), Torricelli Francesco (2), Bigand Félix (3), Abalde Sara (3), Novembre Giacomo (3), D'Ausilio Alessandro (1) (2), Tomassini Alice (1) (2)

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Successful joint action requires the nervous system to integrate information across multiple sensory modalities and timescales to generate coordinated behavior. However, the neuromuscular principles that support such integration, and how they manifest in shared neural population dynamics, remain poorly understood. To address this question, we recorded neural activity (EEG) from dyads performing a finger movement synchronization task and applied kinematics-informed latent space modeling within a contrastive learning framework. Neural embeddings were conditioned on task-relevant kinematic (auxiliary) variables spanning macroscopic (position, velocity) and microscopic (submovement) scales. This enabled the extraction of low-dimensional neural manifolds that were structured by behaviorally meaningful movement features. We found that both the rotational geometry and interpersonal alignment of these manifolds depended strongly on movement scale and coordination mode. During in-phase coordination, partners showed strong in-phase alignment in their latent neural trajectories across both macroscopic and submovement scales. By contrast, anti-phase coordination produced weaker anti-phase alignment, limited to macroscopic movement features and not extending to submovement-level dynamics. These findings suggest that joint action is supported by scale-dependent alignment in behaviorally grounded neural manifolds, with tighter coupling emerging when coordination is in-phase. More broadly, this work demonstrates that contrastive, kinematics-informed latent space modeling provides a principled computational framework for revealing multisensory neural representations that link perception, neuromuscular control, and coordinated action.

Poster #4.16: Effects of positive and negative multisensory character experiences in virtual reality on subsequent self-perception and interpersonal behavior

Ueda Sayako (1) (2)

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2 - RIKEN Center for Brain Science, Wako (Japan)

Previous studies on the Proteus effect have primarily focused on outward characteristics such as attractiveness. In contrast, less attention has been given to how the experiential context associated with a character's attributes may shape self-perception and interpersonal behavior. The present study examined changes in self-perception and interpersonal behavior after participants experienced two contrasting character settings. Participants acted in a VR environment as either a positive or a negative character. In the positive condition, a pleasant odor was presented together with visual, auditory, and olfactory effects emphasizing gentle and benevolent attributes, including flowers blooming, animals approaching, light or butterflies appearing from the hands, and sparkling sound effects. In the negative condition, a burnt odor was presented together with multisensory effects emphasizing dominant and

aggressive attributes, including plants withering, animals fleeing, flames emerging from the hands, and the sound of fire burning. As indices of the Proteus effect, personal space toward three types of targets differing in social similarity to the participant was measured as a behavioral outcome, and subjective ratings assessed attitudes toward others and impressions of the self. Personal space was generally smaller in the positive condition and larger in the negative condition. Subjective ratings also indicated kinder impressions of others and more positive self- evaluation in the positive condition, but more aggressive impressions of others and more negative self-evaluation in the negative condition. These findings suggest that multisensory character experiences in VR can shape both social perception and interpersonal behavior.

Poster #4.17: Multisensory gain as an adaptive response to thermal stress? A VR study on peripersonal space in climate chambers

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The Multisensory Integration Space (MIS), the peripersonal space surrounding the body in which multisensory interactions enhance perceptual processing, is known to be highly plastic. While research shows that threatening stimuli can expand this space, the impact of extreme environmental temperatures remains unexplored. Here, we investigate for the first time whether extreme temperatures increase multisensory gain as an adaptive, automatic mechanism to preserve perceptual efficiency under aversive conditions and provide a protective advantage in challenging environments. Furthermore, we examine whether visually conveyed thermal cues alone are sufficient to modulate the MIS. In a within-subject design (N = 36, data collection ongoing), participants were immersed in a realistic mountain virtual reality (VR) scenario. Ambient temperature was either physically manipulated in climate chambers (cold: 8 °C; hot: 38 °C) or visually suggested (snowy mountains vs. desert-like scenario) while physical temperature was held constant at 21 °C. Moreover, participants also performed the task in the neutral mountain VR scenario while at 21 °C to evaluate their baseline behaviour. To assess the MIS, participants responded as quickly as possible to a tactile stimulus delivered to the cheek while a virtual object approached them. Tactile stimulation occurred at eight temporal delays corresponding to visual distances of 30, 50, 70, 90, 110, 130, 150, and 200 cm. By comparing physical and visual thermal stressors, this study aims to clarify whether multisensory adaptation to extreme environments is driven by physiological state or top-down cognitive cues. Full results will be presented at the conference.

Poster #4.18: Visual and haptic perception of object mass in immersive mixed reality

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Visual cues to object mass strongly shape how we handle objects and how heavy we expect them to feel, yet can also produce systematic misperceptions. In classic size- and material-weight illusions, "lighter-looking" objects (e.g., smaller or less-dense materials) are perceived as heavier than identically weighted "heavier-looking" objects. Here, we test whether dynamic cues to object mass (motion/deformation) produce comparable misperceptions and how misperceptions operate under visuo-haptic conflict in immersive virtual environments. First, we conducted a Virtual Reality (VR) experiment (N=22), to select stimulus pairs that reliably produced comparable visual weight

expectations across size, material, and dynamic conditions, where dynamics were depicted by objects impacting and deforming a cloth surface. Next, 21 new participants viewed those stimulus pairs, while lifting identically weighted physical cubes in a mixed-reality (MR) environment. For this purpose, we developed a novel co-registration method combining VR with high- precision motion capture to test how size, material, and dynamic visual cues to object mass influence perceived heaviness during lifting. We replicated the size–weight illusion (smaller-looking objects judged heavier despite equal mass; $p<.001$) but found no material-weight illusion under purely visual material changes ($p=.718$). Surprisingly, in contrast to classic weight illusions, dynamic cues produced an expectation-consistent bias: the object associated with stronger cloth deformation was judged heavier ($p<.001$) even though participants always lifted the same mass. These findings validate our co- registered MR approach for multisensory research and suggest that dynamic object interaction cues may bias heaviness judgments in a manner distinct from static cues such as size and material.

Poster #4.19: Maintaining identity recognition constancy: dynamic configuration of multisensory networks under varying levels of sensory degradation

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Individual identity can be recognized through both facial and vocal modalities. Understanding how the human brain maintains robust person recognition in degraded environments remains a fundamental challenge in multisensory research. Using fMRI, we investigated how sensory degradation modulates brain audiovisual integration strategies by parametrically varying facial blur and vocal noise. Behavioral results revealed widespread crossmodal enhancement—increased accuracy and reduced reaction time relative to unimodal baselines—while the magnitude of these gains was systematically modulated by sensory uncertainty. Preliminary fMRI conjunction analyses exploring multisensory sub-additivity $(AV>A) \cap (AV>V)$ revealed a distinct neural efficiency mechanism. Significant multisensory suppression effect emerged exclusively at specific uncertainty thresholds: when moderately blurred faces were paired with either moderately or highly degraded voices. Under these conditions, a distributed network—including fronto-temporal and occipito-temporal regions—exhibited reduced activation during integration compared to unisensory processing. This suppression effect likely aligns with predictive coding frameworks, where complementary cross-modal cues efficiently resolve perceptual ambiguity, thereby minimizing neural prediction errors and computational demands. Notably, this neural efficiency was absent at absolute extremes of signal clarity or degradation conditions. The current findings demonstrate that our brain dynamically deploys a resource-efficient strategy to ensure perceptual stability amidst the inherent ambiguity of real-world social signals, including recognizing human identities.

Sensory Impairment & Clinical Populations 2

Poster #4.20: Sleep oscillatory topography reveals both experience-dependent reorganization and experience-independent organization in blindness

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Early visual deprivation induces heteromodal recruitment of occipital cortices during non- visual processing, yet the extent to which such reorganization reshapes sleep cortical dynamics remains unclear. Experience-dependent changes in cortical architecture are reflected in the spatio-temporal properties of sleep oscillations, which provide a window into intrinsic connectivity patterns. To assess the effects of the lack of visual experience, we recorded overnight high-density EEG in 7 early-blind (EB; onset <4 years; 3 women, 36±10 yo); 7 age- and sex-matched sighted controls; 5 late-blind (LB; 3 women, 45±13 yo); 5 matched controls. Recordings were obtained at the participant's home using a 64- channel portable system. Sleep was scored manually and automatically; concordant non- REM epochs were analyzed after standardized preprocessing. Slow waves (0.5–4 Hz) were detected using a validated algorithm, and spectral power in canonical frequency bands was computed. Group differences in topography were assessed using permutation- based electrode-wise comparisons with cluster-mass correction for multiple comparisons. EB participants exhibited significant posterior reductions in theta (4-8 Hz) and alpha (8-12 Hz) power relative to sighted controls ($p<0.05$), whereas LB showed a more restricted occipital reduction in theta power only. Delta (0.5-4 Hz) and sigma (12-16 Hz) activity did not differ between groups. EB also showed a reduced negative-to-positive slow-wave slope over occipital regions. This first high-density EEG study of sleep oscillatory topography in blindness reveals that development of delta and sigma activity is largely independent from visual experience, while early sensory loss leads to selective posterior alterations consistent with experience-dependent reorganization of cortical network dynamics.

Poster #4.21: Disrupted multisensory processing of the bodily self in acquired and developmental disorders

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Self-advantage (i.e., enhanced responses to images of one's own body) has traditionally been attributed to facilitated visual processing of self-related stimuli. Recently, we demonstrated that this effect reflects mechanisms based on somatosensory coding of visual self-identity, whereby tactile processing is enhanced when observing one's own body, indicating a multisensory contribution to bodily self-recognition. Here, adopting a neuropsychological perspective, we investigated pathological conditions that may disrupt this multisensory mechanism. In Experiment 1, we tested post-stroke patients, including a subgroup with selective bodily self-representation disorder (pathological embodiment, E+) characterized by explicit recognition impairment of their hand and misattribution of another's hand to themselves. While stroke patients without body-awareness alterations (E-) preserved the typical self- related tactile facilitation while observing both affected and intact hands, E+ patients showed a selective reduction of somatosensory enhancement only to the affected hand's presentation. This pattern suggests that disruption of explicit bodily self-recognition is accompanied

by implicit somatosensory coding impairment. In Experiment 2, we examined children with congenital motor deprivation (cerebral palsy) to assess whether typical somatosensory coding requires early visuomotor-somatosensory coupling. Compared to E- patients from Experiment 1, cerebral palsy children lacked the self-specific tactile enhancement when viewing their affected hand, showing it only for the intact hand. Together, the two studies show that somatosensory coding of visual self-identity is disrupted either by acquired lesions affecting visuo-somatosensory integration or by atypical developmental sensorimotor experience. Hereby, multisensory associations appear necessary for the emergence and maintenance of bodily self-representation, providing converging neuropsychological evidence for the multisensory basis of self- identity.

Poster #4.22: Listening to the gut: gastric interoceptive accuracy in blindness

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Interoception is the process by which the nervous system senses, interprets and integrates internal bodily signals. While crucial for emotional awareness and body representation (Khalsa et al., 2018), little is known about how it develops in the absence of vision. Recent findings suggest that visual experience influences the bodily representation of emotions, with blind individuals placing less emphasis on the stomach area than sighted (Lettieri et al., 2024). However, it remains unclear whether these representational differences reflect altered perceptual sensitivity or higher level reorganization. To investigate this, we will employ the Rumble Recognition Task (Savage et al., 2025), a novel paradigm assessing gastric interoceptive accuracy, in two conditions: fasted and after drinking 200 ml of sparkling water. Early blind, late blind and sighted participants will perform a two-interval forced-choice task to discriminate real-time from pre-recorded gastric sounds streamed via a digital stethoscope. Gastrointestinal interoceptive accuracy will be quantified as the percentage of correct trials per block, while confidence ratings will be used to assess interoceptive sensibility. We will test group differences in gastric accuracy exploring whether blindness duration modulates performance. Based on altered emotional body maps, we hypothesize that blind individuals will exhibit lower gastric accuracy than sighted controls. Furthermore, while sparkling water will enhance performance across all participants by increasing visceral signaling, it could potentially reveal group-specific modulation. By linking sensory deprivation to gastric accuracy, this study clarifies whether visual experience shapes the perceptual foundations of visceral awareness, advancing our understanding of interoceptive plasticity and multisensory body representation.

Poster #4.23: Modulation of body representations in stroke patients and rehabilitation potentials: a scoping review

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In the brain, continuous streams of multisensory afferent signals and efferent motor outputs are used to construct and update multiple body representations (BRs). Following a stroke, disruptions of BRs are commonly observed and may significantly impact sensorimotor recovery and daily functioning. However, these alterations remain largely overlooked in conventional rehabilitation. Accumulating evidence nonetheless indicates that BRs are plastic and can be deliberately modulated, opening new prospects for interventions designed to reshape them after stroke. The aim of this scoping review is to synthesise approaches for modulating BRs after stroke, identify the BR components investigated, and outline the outcomes achieved. Thirty-four studies were included in total, together targeting twelve distinct BR components. To capture the commonalities and diversities of the approaches, we categorised the interventions based on their mechanisms of action into five overarching groups and fifteen more specific subcategories (e.g., category Visuo-sensorimotor (in)congruency; subcategory Visuo-motor (in)congruency - Mirror therapy). Moreover, for each BR component, we compiled the proposed intervention types and their reported outcomes. Finally, we examined methodological constraints across studies and proposed strategies to strengthen future rehabilitation approaches. Overall, this scoping review provides a comprehensive overview of experimental interventions for modulating BRs after stroke. Although these methods are primarily confined to research settings, existing findings suggest they hold promise for translation into clinical practice. Advancing this line of work will be crucial for developing evidence- based protocols that integrate BR focused interventions.

Poster #4.24: Temporal audiovisual perception in people who have had one eye removed early compared to late in life

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The visual system is not fully mature at birth, and as such, disruption of vision prior to its maturation may alter visual processing and impact the development of complementary senses. A unique model to examine the timelines of sensory development and the role of binocularity in visual system maturation is people who have had one eye surgically removed (monocular enucleation) during early postnatal development. Adaptive auditory processing and audiovisual plasticity following the loss of one eye early in life has been observed. The current study investigates whether multisensory compensation is also present in people who had one eye removed late in life, after postnatal visual system maturation. We measured the temporal binding window in which audiovisual events are integrated and the sound-induced flash illusion in people with late compared to early eye enucleation and binocular controls. Preliminary data indicate a larger temporal binding window with late eye enucleation compared to early eye enucleation and binocular viewing controls. However, unlike binocular viewing controls, people who had their eye removed either early or late in life did not perceive the sound-induced flash illusion. These results indicate that the nature of cross-modal adaptations for the loss of binocularity may be dependent on cortical development stages. This suggests distinct multisensory compensatory mechanisms may be developed based on timing of visual deprivation.

Poster #4.25: Exploring differences in audiovisual integration between individuals with dementia, mild cognitive impairment, and healthy controls

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Multisensory integration processes are known to change across the lifespan and may be particularly vulnerable in individuals experiencing cognitive impairment. The sound- induced flash illusion (SIFI), in which auditory stimuli alter the perception of visual flashes, provides a well-established behavioural paradigm for assessing audiovisual integration and temporal processing. Using the SIFI, previous studies have reported that individuals with mild cognitive impairment (MCI) exhibit a wider temporal binding window compared with cognitively healthy older adults, suggesting reduced temporal precision in multisensory processing (Chan et al., 2015). The present study extends this work by examining susceptibility to the SIFI across three groups: individuals with clinically diagnosed dementia, individuals with MCI, and cognitively healthy older adult controls. More specifically, participants completed a numerosity judgement task, indicating whether each trial contained one or two flashes while they ignored concurrent auditory beeps. Conditions known to produce fission (1 Flash & 2 Beeps) and fusion (2 Flashes & 1 Beep) variants of the SIFI were randomly interleaved with congruent control trials, while conditions containing multiple flashes or beeps were presented at stimulus onset asynchronies of 100, 150, 200, and 400ms. Using this methodology, preliminary results indicate that individuals living with dementia are more susceptible to perceiving the SIFI, which supports and expands previous work on the effect of cognitive impairment on audiovisual integration. If these findings are confirmed, the SIFI could contribute to improved characterisation of sensory and cognitive interactions in dementia and inform future translational research.

Poster #4.26: Integrating vicariant senses into the developmental habilitation process for visually impaired children

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**speaker*

Early identification of sensory impairment is important related to critical periods in sensorial development and brain organization: the earlier interventions begun, the more they will be successful for the child. First year is especially important for critical periods for vision loss, hearing that may compound sensory input, and this may affect intellectual and social development adversely. In vision loss the other sensory channels—touch, hearing, smell, proprioception, and the vestibular system—take on a central role in constructing representations of the world and in cognitive, motor, and relational development. Children born with low vision - early in life before visual memory and concepts are formed - must learn the foundations to movement, to understand objects, and the myriad of relationships beyond arms reach. Appropriate interventions in habilitation process are referred to mental age and global functioning. The assessment phase as the habilitation interventions take into account, beyond the vision functioning, all the developmental milestones and inter-relational goals within the social environment. Depending on the co- morbidities and the possible deprivation of stimuli, the appropriate intervention is set on the evaluation of global functioning of the child, referring to the normotyipical development, as mental age or attended specific performances. Enabling intervention in the early years of life (0-6 years) plays a fundamental role in supporting the overall development of children with visual impairments. From an ecological and neurodevelopmental perspective intervention process is designed to promote alternative experience access: enhancing vicariant senses (tactile, auditory and proprioceptive) and strengthening perceptual-motor skills.

Poster #4.27: Sensory processing organization and adaptive functioning in preschool children with autism spectrum disorder: a repeated-measures study

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Atypical sensory processing in autism spectrum disorder (ASD) is associated with challenges in self-regulation and adaptive functioning. However, empirical approaches capable of systematically capturing relationships between sensory processing organization and functional adaptation remain limited, partly due to the lack of structured frameworks that operationalize clinically observed change. This pilot cohort study examined whether changes in sensory processing organization correspond to measurable improvements in adaptive functioning in preschool children with ASD. The STEP-SI framework was used to structure a multidimensional assessment across domains including sensation, task performance, environmental adaptation, predictability, self-regulation, and interaction, enabling repeated evaluation of functional organization rather than isolated symptoms. Thirty-six children aged 3–6 years participated in an intensive two-week sensory-based intervention consisting of ten individualized sessions. Outcomes were assessed at baseline, immediately post-intervention, and at one-month follow-up. Repeated-measures ANOVA was conducted to evaluate time-dependent changes, and effect sizes were calculated to estimate the magnitude of observed differences. Analyses revealed significant improvements in sensory modulation and regulatory capacities, accompanied by enhanced task engagement, adaptability to environmental demands, and coping with change. Parent-reported outcomes indicated parallel gains in attention, communication, peer interaction, and play. Effects were strongest immediately after the intervention, with partial maintenance at follow-up. These findings suggest that improved sensory processing organization may support adaptive functioning in young children with ASD. Rather than reflecting isolated sensory changes, the results point toward broader functional reorganization relevant to everyday participation and highlight the value of structured assessment approaches in research on sensory-related mechanisms underlying adaptive development.

Poster #4.28: Importance of environmental factors in quality of life of children with cerebral visual impairment (CVI): a global approach in rehabilitation

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A structured intervention approach for cerebral visual impairment (CVI) includes the systematic analysis of environmental factors that modulate visual functioning in daily life activities. In the rehabilitation setting are addressed sensory complexity, movements and strategies aimed to promote effectively functional vision within ecological contexts. The primary goal is to optimize the assessment of child's global functioning, integrating clinical observation related to with main neurodevelopmental stages. Particular emphasis at early stages is placed on multisensory integration processes, considered crucial for the organization of perceptual-motor skills, attention and communication. Environmental analysis allows in the process to identify facilitators and barriers, formulating targeted recommendations for contextual adaptations aimed at supporting the effectiveness of the intervention and the child's active participation. Training is entrusted to a multidisciplinary team composed of orthoptist, ophthalmologist, occupational therapist, neuropsychiatrist, physiotherapist, speech therapist, and developmental neuro- and psychomotor therapist. The rehabilitation

intervention is structured as a holistic and integrated process, combining visual and non-visual strategies, enhancing residual functioning and promoting compensatory modalities. Three main pillars: (1) a multidisciplinary approach that actively includes caregivers; (2) the need ecologically valid assessment tools, to translate clinical observations into concrete operational recommendations; (3) the recognition of the multidimensional complexity of CVI, focused on visual function but also motor, communication, and adaptive skills. The integration of professional skills and analysis of life environment highlights the value of a child-centered interdisciplinary model. Strengthening assessment strategies and optimizing everyday environments are key elements in improving the quality of life, autonomy, and participation of children with CVI.

Poster #4.29: Neural processing of vertical and horizontal auditory cues in sighted and visually impaired preschoolers

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Efficient interaction with the environment relies on integrating multiple spatial information. Although less precise than vision, audition provides important cues for orientation and objects interaction. From early childhood, children can localize sounds along the horizontal (azimuth) plane, whereas vertical sound localization is more challenging. In this pilot study, we examined how five sighted (S) (mean age (SD): 4.87 y.o. (0.65)) and five pink noise along the horizontal and vertical axes. To assess the effects of vision and spatial plane on neural activity, we recorded high-density EEG and computed event- related potentials (ERPs). Specifically, children were presented with a spatialized sound emitted from one speaker within a 5×5 speaker array and touched the speaker they perceived as the sound source. We calculated localization accuracy and response times. ERPs were analyzed separately for each axis and group after preprocessing. Behaviorally, both groups showed poorer localization on the vertical than on the horizontal axis. VI children showed slightly better accuracy on the horizontal axis but worse accuracy on the vertical axis compared to S children. Response times did not differ between groups or planes. Neurally, in the vertical localization condition, S children exhibited enhanced ERP amplitudes compared to VI children. This effect was observed over medial central–posterior scalp regions, areas typically associated with spatial processing and multisensory integration. These preliminary findings suggest that vision plays a stronger role in shaping neural responses during vertical than horizontal sound localization. This work of the MELD (Multisensory Environments to study Longitudinal Development) was supported by a generous unrestricted gift from Reality Labs Research, a division of Meta.

Poster #4.30: iReach: making space accessible using target-referenced audiotactile distance cues without vision

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In congenital visual impairment (VI), early sensory deprivation can alter the development of visuomotor and spatial systems, leading children to rely more on non-visual cues to control goal-directed actions. This perspective motivates rehabilitation approaches to enrich sensorimotor

experience and support active, self-initiated exploration of the environment. Within this framework, we designed iReach, a multisensory wearable device that delivers distance-dependent audiotactile feedback about an external target, providing movement-contingent cues to support action accuracy in VI. Here, we tested the device during a playful task, wherein 28 blindfolded sighted preschoolers (age range 3-6 y.o.) were asked to pick up objects and drop them into a box positioned 1 meter in front of them. Children were randomly assigned to one of three conditions : iReach, ABBI (a body-centered audio wearable), or no device. To explore whether iReach was associated with increased accuracy relative to ABBI and no device we entered task accuracy as dependent variable in a binomial generalized linear mixed-effects model. Indeed it provides external target- referenced feedback rather than only body-referenced cues and results supported our prediction: we found higher accuracy with iReach than with ABBI ($p = 0.04$) and no device ($p = 0.01$), with similar performance using ABBI or without any device. We will perform the same study in children with VI, expecting that target-referenced audiotactile feedback from iReach will support accurate goal-directed performance also for them.

Eye Movements & Prediction

Poster #4.31: Saccades produce costs and benefits for auditory perception

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Saccadic eye movements modulate neural activity far beyond the visual system, influencing widespread brain networks including subcortical and cortical auditory regions. However, the functional consequences of these interactions for auditory perception during natural behavior remain poorly understood. Here, we investigated how auditory perception varies relative to saccade onset during active visual exploration. Participants performed auditory discrimination tasks while freely viewing natural scenes. Images were presented for 8 s and followed by content questions to promote active exploration. During each image presentation, 1–2 brief auditory probes were delivered through headphones at random times. We examined perceptual performance as a function of saccade direction and timing relative to probe onset. In Experiment 1, participants localized 10-ms pink-noise bursts presented binaurally with an interaural time difference, creating the percept of a sound originating from the left or right. In Experiment 2, participants discriminated the pitch (2 vs. 2.5 kHz) of a 6-ms tone presented monaurally. Saccades directed away from the sound were associated with reduced perceptual performance in both tasks. In contrast, saccades directed toward the sound improved performance in the spatial localization task but not in the monaural pitch discrimination task. This pattern suggests that saccadic eye movements selectively facilitate auditory processes requiring binaural integration rather than producing a global modulation of auditory perceptual sensitivity. Ongoing experiments aim to dissociate perceptual mechanisms from response-related processes underlying these effects.

Poster #4.32: Multisensory enrichment of AI-generated advertisements enhances engagement and modulates visual attention

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Our lived experience is an inherently multisensory one. Advertising increasingly leverages this through short-form video content on social media. Yet, the question how multisensory enrichment of advertisement videos influences perception and engagement remains underexplored. In this project, we aimed to examine how the addition of ambient, semantically congruent, auditory and olfactory channels influences subjective perceptual ratings of advertisement videos. Using eye-tracking, we explored if these effects were mirrored in physiological measures of arousal and visual attentional allocation. In this laboratory study (N = 45), participants wearing eyetracking glasses watched a simulated social media feed containing multiple SORA-generated video advertisements, an innovative approach enabling realistic yet brand-neutral stimuli. Videos, e.g. a bee conservation campaign, were presented only as video (unimodal), enriched with congruent music clips or product-related odors placed beneath the participant's nose (bimodal), or enriched with both modalities (trimodal). With increasing number of sensory modalities, we observed a stepwise increase in behavioral ratings of video quality, product likeability, and purchase intent, mirrored by an increase in pupil dilation. Eye-tracking revealed that trimodal stimulation increased saccade rate and fixation dwell time while reducing the number of fixations. These findings suggest that multisensory enrichment enhances both subjective engagement and physiological arousal. The observed eye-tracking pattern of more active exploration paired with more selective attentional allocation is consistent with deeper cognitive processing of advertising content, highlighting the potential of congruent multisensory cues to enhance advertising effectiveness in digital environments. Future work should examine whether these effects translate to real-world purchasing behavior.

Poster #4.33: Auditory cues shape predictive gaze during immersive navigation

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**speaker*

Natural vision is an active, predictive process guided by expectations about when and where information will appear. Yet how gaze is shaped in dynamic, multisensory environments remains poorly understood. Using immersive virtual reality with eye-tracking, we examined oculomotor behavior during naturalistic navigation. Participants cycled through a virtual city while avatar cyclists, first heard as overtaking them from behind via spatialized auditory cues, later became visible as they passed. Auditory cues triggered anticipatory gaze shifts to expected locations, indicating that eye movements were guided by auditory predictions rather than reactive visual responses. Violations of auditory–spatial expectations elicited longer fixations. Critically, removing auditory cues impaired predictive gaze orienting, delayed gaze orienting and increased collisions with obstacles. These findings demonstrate that auditory input fundamentally shapes predictive models guiding visual exploration and adaptive behavior in dynamic environments, underscoring the multisensory basis of active perception in real-world interactions.

Poster #4.34: Visually guided voluntary actions boost short-term ocular dominance plasticity

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Short-term monocular deprivation transiently shifts ocular dominance in favor of the deprived eye. Here we asked whether the effect of a one-hour monocular deprivation was enhanced by the execution of a task requiring visually guided goal-directed actions, compared to a passive viewing condition where participants watched a replay of their own actions. Although the visual input was the same across conditions, we found a stronger ocular dominance shift when participants actively performed visually guided goal-directed actions. These results provide strong evidence that voluntary, goal-directed actions modulate visual plasticity.

Poster #4.35: Perceptual prediction of occluded items and its relation to action execution

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Visual input that reaches our retina is often interrupted due to occlusions. Yet visual experience remains continuous and stable. Previous research has indicated that processes such as object persistence and motion extrapolation help achieve perceptual stability. We have recently demonstrated that information upon occluded objects is retained in an early medium in the visual cascade. In our experiment two colored disks that passed behind occluders could still alter the perception of a briefly flashed target even if this was presented one second after the flankers had disappeared. The bias was strongest when the target appeared along the predicted trajectories of the moving objects, but it disappeared when the inducers stopped before the occluders or when the target was flashed off trajectory, demonstrating that the stored information is bound to a dynamic spatio-temporal representation of the occluded object (Sertakan et al., Curr Biology, 2026)1. In this work we asked whether mechanisms that trigger this form of sensory memory are linked to action systems, as these have often been suggested to provide simulating capabilities underlying perceptual processes. To this aim we first replicated our experiment with static inducers and targets covered by a moving occluder. We then measured the effect when observers controlled the occluder via mouse movements. To our surprise, results showed that the influence of the hidden flankers was not boosted when observers controlled the occluder. Possible reasons for the failure to augment predictive mechanisms will be discussed. 1Sertakan, H., Burr, D. C., & Cicchini, G. M. (2026). Human vision maintains a rich representation of objects moving behind an occluder. Current Biology, 36(5), R185–R186. https://doi.org/10.1016/j.cub.2026.01.032

Poster #4.36: Cross-modal influences on eye movements in the absence of visual awareness

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The eyes are typically drawn towards the most salient and relevant parts of a visual scene. However, some visual stimuli also attract the eyes in the absence of visual awareness. Here we show that unseen images guide the eyes when these images are paired with a congruent sound, a congruent action or when they are of increased relevance, emotionally or socially. We rendered images invisible using continuous flash suppression and verified full suppression from awareness by objective and subjective measures. Eye tracking results revealed that the eyes are repelled by angry faces and attracted by fearful faces and by faces of a different race. Eyes are also attracted by neutral faces when paired with a congruent voice, by threat-related car images when paired with a congruent sound and by action-related body part images when paired with an action. In sum, our findings show that when the representations of unseen images are sufficiently strengthened, either by cross-modal congruence or emotional or social relevance, they have the power to guide eye movements even in the entire absence of visual awareness.

Poster #4.37

Poster #4.38: Explicit look-ahead reporting changes gaze and manual tracking behaviour in visuomotor delay adaptation

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Visuomotor adaptation consists of implicit (slow/unconscious) and explicit (fast/conscious) processes. Their contributions to adaptation have been studied using visuomotor rotation tasks with aiming reports. We set out to transfer this paradigm to a 1-D continuous target tracking task with visuomotor feedback delay in a predictable environment. Two groups of participants tracked a target with their cursor which was either not delayed (Block 1 & 5), not visible (Block 2 & 4) or delayed by 200 ms (Block 3). We computed lead/lag of the hand relative to the target to track delay adaptation. One group additionally reported before every trial how far they will look ahead of the target to successfully perform the task. Using eye-tracking we furthermore measured the actual look-ahead behaviour. Overall, explicit reports lead to small but significant advantages in manual target tracking under visual feedback delay. Gaze behaviour of the two groups differed in the delay and the subsequent invisible-cursor block. In the delay condition, the reporting group looked further ahead of the target. In the subsequent invisible-cursor-block they looked less far ahead compared to the no-reporting group. The reports overestimated the actual look- ahead behaviour in the delay condition but otherwise matched. Together, these results indicate a benefit of explicit strategies for target tracking under visual feedback delay. The reporting seems to alter gaze behaviour which in turn might lead to the advantage in target tracking. However, the effects of explicit reporting were smaller than what has been reported for visuomotor rotation tasks.

POSTER SESSION 5

JUNE 27th | 10:30 am – 11:45 am

HALL

Vestibular Processing, Balance & Locomotion

Poster #5.1: Passive guidance with a sensory substitution device influences shape perception, proprioception, and motor performance

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Sensory substitution devices (SSDs) provide a unique framework to investigate attention, perception, and sensorimotor interactions. While previous studies have examined how stimulus type and exploration strategy during active manipulation affect perception, proprioception, and motor performance, these factors remain unexplored in the context of passive guidance through an SSD. In this exploratory study, we investigated how stimulus type (auditory only [A] vs auditory and tactile [AT]) and passive exploration strategy used to guide participants (micro- scanning, oscillatory movements along the shape's contour [MIC] vs macro-scanning, large oscillatory movements crossing the shape from side to side [MAC]) influence the perception of 2D shapes. Proprioceptive acuity was measured before and after passive guidance, and motor performance was assessed in a subsequent tracing task. Participants were assigned to four groups (n = 12 per group: MIC-A, MIC-AT, MAC-A, MAC-AT) and completed three passive guidance sessions. Results showed that MIC outperformed MAC for shape recognition across passive training sessions, with the strongest effect observed in the group receiving MIC combined with AT stimulation. Improvements in proprioceptive acuity and tracing performance were also greater following MIC training, particularly with AT stimuli. These findings provide new insights into perceptual processing, attention, and sensorimotor interactions under passive guidance, highlighting the potential of SSDs to study multisensory integration and proprioceptive function. They also highlight directions for future research on the impact of passive guidance on perception and motor behavior.

Poster #5.2: Vestibular perturbations alter visual exploration and pupillometric signatures of affective images

Petrizzo Irene (1), Blini Elvio (1)

1 - Università degli Studi di Trento (Italy)

Perception is not a passive recording of external events. It is a continuous, active, and dynamic act of inference shaped by current goals, past experience, and hard biological constraints. Our body – its current physiological state – is arguably the most fundamental one. Continuous inference on the causes of interoceptive states colors our perception with emotions, which in turn affects basic perceptual and attentional processes. How, then, do we really look at the world when experiencing malaise? Here we leverage on Galvanic Vestibular Stimulation, a non-invasive brain stimulation technique that induces mild dizziness, motion sickness, and nausea by stimulating the vestibular system. The use of GVS in conjunction with high-resolution eye tracking, pupillometry, and

computational modelling allows us to demonstrate that such vestibular perturbation generally decreases the visual exploration of space when compared to sham stimulation. However, this decoupling from the external visual world is context-sensitive: highly salient, negatively valenced images can pierce this state of increased attention to the self and counteract it by promoting increased exploration of visually salient features instead. Pupillometry revealed an increased tonic state, consistent with heightened arousal, accompanied by altered phasic responses to negative emotions. There was a close relationship between subjective reports of nausea, oculomotor behavior, and physiological measures, foreshadowing an important role of individual differences and modulators (e.g., interoceptive sensitivity). The results therefore unveil the continuous interplay between interoceptive and exteroceptive processing, and show that how we perceive the environment fundamentally resonates with how we feel.

Poster #5.3: Action context shapes tactile localization during naturalistic self-touch

Khoury Jason (1), Zástěrová Adéla (1), Fuchs Xaver (2), Tcaci Popescu Sergiu (1), Hoffmann Matej (1)

1 - Czech Technical University in Prague (Czech Republic)
2 - Universität Salzburg (Austria)

Tactile localization in everyday life is embedded in a sensorimotor loop: when we scratch an itch for instance, target and effector limbs often move simultaneously while tactile, proprioceptive, and motor signals are continuously updated. By contrast, most experimental paradigms constrain participants' responses in ways that depart considerably from naturalistic actions – either by preventing direct pointing to the stimulation site, or by constraining movements of the targeted body part. Hence, we are investigating whether a more naturalistic bimanual response improves tactile localization relative to standard unimanual reaching. Participants localize brief tactile stimuli delivered to three sites on the dorsal forearm in three direct-reaching conditions: (1) unimanual reaching with the target arm extended in front of the body; (2) bimanual reaching, in which both arms move concurrently toward the body midline; and (3) reaching to a target arm fixed at the midline in the same final posture as in the bimanual condition, but without concurrent movement. We predicted that bimanual reaching would yield greater accuracy by engaging sensorimotor contingencies and online proprioceptive updating that better resemble everyday self-touch. Preliminary results show the opposite pattern: signed and absolute errors were smallest in the unimanual extended condition across all three stimulus sites. Kinematic analyses of full arm joint trajectories, target positions, and index finger paths are currently underway and may help clarify the mechanisms underlying these differences. This work asks how action context shapes tactile localization and may help guide the design of more ecologically valid multisensory paradigms.

Poster #5.4: Cortical basis of visuo-vestibular integration for self-motion perception: insights from a fNIRS study across gravity and aging

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Understanding how the cortex integrates vestibular and visual inputs to generate self- motion perception remains a key issue in human neuroscience. Galvanic vestibular stimulation (GVS) is a controlled method to activate vestibular afferents and induce direction-specific sensations of body motion. Previous fMRI work from our team using binaural bipolar (lateral, LAT) and binaural

monopolar (anteroposterior, AP) GVS revealed a cortical network including CSv, hMT+, and PIC for both directions, with selective recruitment of V6 and VIP during AP stimulation, suggesting a preferential role for forward self-motion processing (Aedo-Jury et al., 2020). Combining directional optic flow with vestibular stimulation has been shown to enhance cortical responses associated with forward self-motion, particularly in area V6 when visual and vestibular cues are congruent (Marchand et al., 2025). However, fMRI requires a supine posture, which may bias vestibular processing due to gravity-dependent modulation of otolithic signals.To overcome this limitation, the present study uses functional near-infrared spectroscopy (fNIRS), allowing recordings in both seated and supine positions. Participants undergo visual self-motion stimulation using optic flow and vestibular stimulation using GVS (AP and LAT). Cortical activity is measured over occipito-parietal regions of interest targeting V6, hMT+, and VIP. In addition, we investigate aging effects by comparing healthy young and older adults. Age-related vestibular decline and changes in cortical integration may alter the magnitude or selectivity of visuo-vestibular responses. This study aims to validate fNIRS for investigating vestibulo-cortical networks, assess gravity-related modulation of self-motion processing, and characterize age-related changes in visuo-vestibular cortical dynamics.

Poster #5.5: Visual-vestibular integration and balance control in concussion

*Vovan Sonia (1), Sergio Lauren (1), Campos Jennifer (2)**

1 - York University (Canada)
2 - KITE-Toronto Rehabilitation Institute, University Health Network (Canada
**speaker)*

Background/Objectives: Individuals with concussion often report dizziness and instability in visually complex and moving environments, suggesting altered sensory weighting and increased visual dependence. This study examined how predictable and unpredictable optic flow perturbations, presented at varying speeds, affect postural control in individuals with concussion compared to healthy controls. Methods: Ninety adults (25–65 years; 50% female) were classified as Controls (n=30), Low Symptom Burden (LSB; n=30), or High Symptom Burden (HSB; n=30). Participants were immersed in a 240° VR environment while standing on a force plate. Optic flow was presented at three speeds (1.5, 3.0, 4.5 m/s) with predictable and unpredictable timing. Centre of pressure (COP) path length and immediate perturbation responses (peak amplitude, latency, balance correction time) were measured. Results: The HSB demonstrated longer COP path lengths than Controls, but only at the fastest optic flow speed. Only the HSB demonstrated longer COP path lengths with increasing speed. The HSB also had longer balance correction times compared to Controls, but only at the fastest speed, when unpredictable. No group differences in peak amplitude or latency were observed, suggesting that group-related differences were evident in the ability to recover balance after a visual perturbation rather than the magnitude or speed of the initial postural response. Conclusion: Individuals with HSB exhibit prolonged postural responses to optic flow, suggesting less efficient visual-vestibular reweighting, particularly under demanding conditions.

Poster #5.6: Tipping the sensory scales: low-intensity stochastic vestibular stimulation improves balance as a function of visual feedback availability

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Maintaining balance requires the coordinated integration of visual, vestibular, and other sensory signals (e.g., proprioceptive), with vision typically playing a dominant role. Noisy galvanic vestibular stimulation (nGVS) employs stochastic resonance (SR) to enhance vestibular signal detection. nGVS has been shown to improve centre-of-pressure (COP) measures across various stances, surfaces, and vision conditions. Based on multisensory integration mechanisms, one can expect improvements in balance during nGVS when vision is unavailable (i.e., eyes closed [EC]). In contrast, fewer studies report improved balance with nGVS and when vision is available (i.e., eyes open [EO]). Moreover, nGVS studies have typically employed fixed stimulation intensities that may be perceptible and even unpleasant. As a result, the current study assessed how vision (EO vs. EC) modulates the benefits of individually-adjusted, low-intensity nGVS to balance. To do so, we orthogonally combined nGVS/no nGVS conditions with EO/EC conditions. Twenty-six healthy adults (14 female, mean age 24.2 years) were tested for their cutaneous GVS detection threshold, and 80% of that intensity was employed for nGVS. Participants maintained a tandem stance on a force platform during 12 trials, with 3 trials per condition. Results showed that COP metrics (e.g., sway velocity and path length) were significantly improved/reduced with nGVS, but only in the EC condition. By orthogonally combining visual and nGVS conditions, this study replicated the benefits of nGVS to balance with individualized stimulation but only when vision was unavailable. Thus, higher-intensity nGVS may be required to mitigate the typical visual-vestibular reweighing when vision is available.

Poster #5.7: Divergent sensory strategies are employed by three strains of mice to capture prey

Huang Kierian (1), Hoy Jennifer (1)

1 - University of Nevada, Reno (United States)

The ability to accurately orient towards salient objects in the environment is enhanced by the multisensory processing of environmental inputs. Specifically, the brain computes whether specific visual and auditory signals originate from the same egocentric location in the environment. When this information is spatially aligned, animals orient more accurately and rapidly toward stimuli. This indicates that successful integration of spatially coherent visual and auditory information is a form of multisensory processing that enhances perceived stimulus salience. While we understand much about how maps of visual space are represented in the vertebrate midbrain to drive orienting, we do not fully understand how spatial representations of auditory information emerge in these same areas. To study this process mechanistically, we developed a natural prey capture paradigm in mice to quantify spatial orienting behaviors dependent on specific sensory cues that can be dissected at the neural circuit and genetic levels. Here, we present work demonstrating that strains of mice differing either in genetic background, or in sensory capability within the same genetic background, display distinct differences in insect (prey) orienting. These behavioral differences specifically reflect variations in the ability to process high-frequency spatial information in either the visual or auditory domain. We conclude that while mice flexibly utilize unimodal cues to orient towards prey, they perform optimally only when they possess both high-frequency hearing and vision. This work informs our next steps in understanding how visual and auditory spatial information develops in the midbrain of mouse strains naturally equipped to integrate multisensory cues.

Poster #5.8: Effects of walking visuomotor asynchrony on anticipatory brain processing of a concomitant cognitive task

Moscogiuri Martina (1), Perrone Martina (1), Costanzo Raffaele (1), Di Bello Biancamaria (1), Fattori Patrizia (2), Galletti Claudio (2), Strappini Francesca (1), Sulpizio Valentina (3), Di Russo Francesco (1) (4), Pitzalis Sabrina (1)

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4 - IRCCS Fondazione Santa Lucia (Italy)

Dual-tasks such as walking during the execution of a cognitive task have been investigated to test the multitasking brain capacities. Here we sought to test whether the introduction of temporal asynchrony between the walking speed and the perceived optic flow may affect the performance and anticipatory brain to a concomitant visuomotor discrimination task (DRT). To this aim, 17 healthy university students performed a DRT while walking on a treadmill at a fixed speed (1.2 km/h). Optic flow was manipulated to create three visual–motor conditions: same speed, faster, and slower relative to walking speed. Event-related potential was used detect preparatory activity to the DRT, and the anxiety levels was measured before the experiment and after each condition to monitor fluctuations in anxiety and students' subjective well-being. Results showed that behavioral performance remained stable across conditions. However, differences emerged in anticipatory neural activity. The prefrontal negativity (pN component) associated with cognitive preparation such as top-down attention was larger when the optic flow was faster than the walking speed suggesting enhanced proactive cognitive control. In line with previous findings this enhancement likely reflects compensatory top-down engagement to manage the temporal incongruence between visual and locomotor cues. Anxiety scores significantly decreased after Faster and Same speed conditions compared to pre-experiment scores, indicating overall reduced state anxiety. These findings suggest that, even when cognitive performance remains stable, visuomotor asynchrony during walking affects both anticipatory neural activity and students' subjective state, highlighting the sensitivity of pre-stimulus ERPs to multisensory temporal alignment.

Poster #5.9: Suppressing the vestibular-ocular reflex via visual imagery: the difference between absent and weak visual imagery matters!

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Visual imagery, the ability to voluntarily generate inner images without sensory input, varies among individuals, with 1-4% reporting aphantasia, i.e. minimal or absent voluntary imagery. Current assessments rely primarily on self-reports and questionnaires. Thus, we investigated if the suppression of compensatory eye-movements by an imagery task can serve as a behavioural marker for aphantasia. While rotating in the dark an imagined object can act as a fixation target, reducing the vestibular-ocular reflex (VOR). We therefore hypothesized that in aphantasia weaker VOR suppression (higher gain) occurs due to a lack of a clear inner image, but that no group effect arises in a cognitive task. We compared VOR gain between an aphantasia group (n=21) and controls (n=28) across four conditions: sitting in the dark, fixating on a light source, imagining an apple (imagery task), and generating names

(cognitive task). Preregistered analysis showed a replication of task effects but no differences in VOR gain between aphantasia and control. Exploratory analysis showed that absent mental imagery (VVIQ , n=10) led to lower gain (26%), 16 while weak imagery (VVIQ , n=11) led to higher gain (46%) compared to controls (VVIQ , n=28) (35%). This suggests that absent imagery prompts alternative, more impactful, suppression strategies whereas weak imagery leads to less vivid inner representations and weakened suppression. Our findings confirm the influence of imagery and cognitive tasks on VOR suppression and suggest that vividness of imagery plays an important role in the former. We propose that distinguishing absent from weak visual imagery is relevant in research on aphantasia.

Poster #5.10: Seeing gravity: right superior temporal sulcus tracks whole-body visual falls without moving the body

Demaria Rémi (1) (2), Bogacki Leïlo (1) (2), Le Meur Gaspard (1) (2), Voudouris Dimitris (3), Aguilar Carlos (2), Blouin Jean (1) (2), Hatzitaki Vassilia (4), Mouchnino Laurence (1) (2) (5)

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2 - Centre de Recherche en Psychologie et Neurosciences (France)
3 - Experimental Psychology, Justus Liebig University Giessen, Germany (Germany)
4 - School of Physical Education & Sports Sciences, Aristotle University Thessaloniki, Greece (Greece)
5 - Institut Universitaire de France (IUF) (France)

It is known that graviceptive information is stored in the vestibular cortex and can be activated by the visual motion of an object falling with natural gravitational acceleration (1g). It remains unclear whether, during quiet standing prior to step initiation, the visual motion of whole-body fall at 1g recruits vestibular cortical regions inducing changes in body representation relative to gravity and thereby step execution. Participants (n = 23) were immersed in a virtual forest while standing. The participants were either at the top of the forest and descended at 1g (Fall) or, at the ground level and ascended at –1g (Elevation). In a control condition, the visual scene remained Stationary. In all conditions, participants initiated a step forward upon the appearance of a black screen, which occurred 2 seconds after visual stimulation. Using electroencephalography, we found increased activity in the right superior temporal sulcus (rSTS), known to integrate visual and vestibular signals, only in the Fall compared with the Stationary condition. Behavioral analyses revealed shorter latencies and longer durations of the body weight transfer prior to stepping in both Fall and Elevation than in Stationary conditions. This pattern likely reflects the unusual visual context shared by the Fall and Elevation conditions, along with similar visual input (comparable VEPs), rather than differences in 1g versus -1g stimulation. The increased activity of the rSTS suggests that visual fall of the standing body engages cortical areas involved in gravity-based verticality, without inducing direction-specific changes in motor output.

Poster #5.11: When movement competes with sensing: body rocking reduces multisensory facilitation

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2 - University of Kansas, Lawrence (United States)
**speaker*

Audiovisual integration is sensitive to competing task demands, with simultaneous motor tasks slowing sensory processing. It remains unclear how movements influence multisensory reaction time (RT) facilitation. In order to investigate how instructed rhythmic movements modulate multisensory

facilitation, twenty participants responded to suprathreshold auditory, visual, and audiovisual stimuli via button press during counterbalanced blocks of seated stillness and rocking. RTs significantly differed for modality ($F(2,38) = 76.30$, $p < 0.001$), with faster responses to audiovisual stimuli than visual and auditory. RTs were slower when rocking than still ($F(1,19) = 9.17$, $p = 0.007$), with significant movement x modality interaction ($F(2,38) = 5.49$, $p = 0.008$). This interaction was driven primarily by the audiovisual condition, where rocking elicited significantly slower responses than still ($t(19) = 5.04$, $p < 0.001$), while the auditory ($t(19) = 2.66$, $p = 0.015$) condition showed a smaller movement effect, and the visual condition ($t(19) = 1.14$, $p = 0.269$) was insignificant. This is supported by violations of the Miller's race model inequality (RMI), where paired cluster-based permutation analysis showed greater race model violations during stillness than rocking from 232-279 ms (Max = 0.069 (234 ms), $p = 0.041$). These findings suggest externalized, instructed rhythmic movements may introduce additional task demands that attenuate audiovisual facilitation. This research was supported by an unrestricted gift from Reality Labs Research, a division of Meta.

Poster #5.12

Poster #5.13: Sustained multisensory clashes in immersive virtual reality

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As we orient and navigate we rely on different sensory channels such as vision, audition, vestibular, and proprioceptive signals. What happens when some of these channels become unreliable? Does performance deteriorate, are conflicts suppressed, or can misleading cues be utilized? Although sustained sensory clashes are rare in everyday life, they are common in extended reality (XR), with practical implications for XR applications and for assistive technologies. Prior work used desktop virtual mazes to isolate visual and auditory channels. Here we extend that approach by adding idiothetic self-motion cues (vestibular and proprioceptive) and haptic feedback via a head-mounted display. This setting enables comparisons of sustained clashes among vision, audition, and touch, including conditions where modalities are reliable, unavailable, or misleading. Results confirm vision's dominance for navigation, consistent with prior research. When vision was available and reliable, it dominated behavior: participants navigated efficiently and accurately, and conflicting auditory or haptic cues were suppressed easily. When visual information was misleading, accuracy deteriorated, indicating that deceptive visual boundaries impair spatial decisions. In the absence of vision, non-visual modalities assumed complementary roles. Haptic cues supported more efficient locomotion than audition alone, suggesting that continuous tactile feedback provides a stable spatial anchor. Combining reliable auditory and haptic cues improved performance relative to either modality independently, demonstrating multisensory integration. Conflicts between non-visual cues were asymmetric: misleading auditory information disrupted haptic navigation, whereas misleading haptic signals had weaker impact on auditory-based performance. These results broaden our understanding of sensory channel relationship during sustained multisensory clashes.

Poster #5.14: Variability matters: effects of real-time sonification in supporting stable straight-line locomotion in the absence of vision

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Proprioception, the perception of internal signals arising from one's own movements, is central to spatial orientation, particularly when vision is unavailable. Little is known about how children with visual impairment (VI) might leverage real-time sonification to enhance proprioception and consequently reduce movement variability, a hallmark of adaptive motor control. Here, we used SONIA, a framework integrated with a motion capture system for real-time sonification, to examine variability modulation during straight-line walking without vision. Eleven typically developing (TD) blindfolded children (9.2 ± 1.7 years) and ten children with congenital blindness (9.2 ± 2.8 years) walked along a straight path 20 times with (ON) and without (OFF) sonification. Trial-level trajectory dispersion was quantified in terms of the Median Absolute Deviation (MAD). A linear mixed-effects model revealed a significant main effect of Condition, with lower MAD in ON compared to OFF ($b = -32.71$, $t(397) = -3.40$, $p < .001$). The main effect of Group was not significant ($b = -30.22$, $t(23.06) = -1.38$, $p = .18$). Importantly, a significant Group × Condition interaction emerged ($b = 27.81$, $t(397.03) = 2.09$, $p = .037$), indicating differential benefits of sonification. Follow-up comparisons showed that VI children exhibited a marked reduction in MAD from OFF to ON ($t(397) = 3.40$, $p < .001$), whereas TD children showed no condition-related change ($t(397) = 0.53$, $p = .59$). These findings demonstrate that real-time sonification effectively transforms movement dispersion into functional stability in children with congenital blindness, supporting proprioceptive regulation when vision is absent. In line with Bernstein's classic view of motor control as the search for stability through variability [1], sonification appears to provide an additional informational channel that helps the motor system reorganize and exploit variability adaptively. [1] Bernstein, N. A. (1996). Dexterity and its development (M. L. Latash & M. T. Turvey, Eds.). Lawrence Erlbaum Associates.

Temporal Processing

Poster #5.15: Capturing rhythm categorisation in the human brain from auditory and tactile signals

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4 - Department of Musicology, University of Oslo (Norway)
5 - International Laboratory for Brain, Music and Sound Research (BRAMS), Montreal (Canada)

Music is a cultural universal, and humans show an outstanding capacity to perceive, learn, and produce musical rhythms. These skills rely on mapping the sheer diversity of possible rhythmic sensory inputs onto a finite set of internal categories of rhythm. While rhythm categorisation has been extensively investigated in audition, rhythmicity in music often involves other senses including vision (e.g., movements from people dancing or making music) and touch (e.g., vibrations produced by loud music). To investigate whether rhythm categorisation generalises across the senses, we measured neural and behavioural responses to auditory and tactile rhythms. We recorded electroencephalographic responses in a group of 20 healthy adult participants while they were exposed to rhythmic sequences whose pattern of relative interval durations ranged from isochronous to long-short rhythms (1:1 – 2:1

interval ratios). A behavioural index of categorisation was obtained by asking participants to synchronise finger tapping with the same stimuli in separate trials. Crucially, each participant took part in two sessions where the rhythmic stimuli consisted of either pure tones or burst of vibrations delivered unilaterally to all fingertips, respectively (the order of the auditory and tactile sessions was counterbalanced across participants). The data were analysed using a novel approach combining frequency-domain and representational similarity analyses. Preliminary results suggest categorisation of rhythms conveyed through auditory and tactile stimuli. Further analyses will elucidate about the similarities and differences of the categorical representations of rhythm from audition and touch.

Poster #5.16: Can novices assess musical performances from a 6-second auditory, visual, or audiovisual clip?

Wilbiks Jonathan (1), Yi Sung Min (1)

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Research focusing on "thin slicing" suggests that we are able to make relatively reliable decisions based on a small amount of information in assessing others' moods, personality traits, and relationships. In considering musical performance quality, previous research (Thompson et al., 2005) has shown that auditory and visual cues both contribute to what is perceived as a high-quality performance. In a paper published by Tsay (2014), thin slicing was found to be present in the assessment of musical performances. They found that musical novices presented with 6 seconds of musical performances were able to assess the winner of a music competition based on visual information only (but not when presented with auditory information or audiovisual information). The current study presents a high-powered registered replication of this previous finding. We presented 6- second musical clips to 96 participants who were musical novices and evaluated their ability to assess musical quality based on auditory, visual, or audiovisual presentation. We found that participants were unable to assess quality at a level greater than chance in any of the three sensory modality conditions (auditory M = .309; visual M = .332; audiovisual M = 0.34; all ps >.34). While visual cues were sufficient to assess quality of performance in Tsay's (2014) study, we found no such evidence here. This suggests that the previous work may have yielded a false positive, and that further research is required in order to disambiguate the factors in multiple modalities that contribute to the assessment of musical quality.

Poster #5.17: Tempo-dependent thresholds for anisochrony discrimination across auditory and visual rhythms

Tokushige Saki (1), Yamamoto Kosuke (1), Watanabe Katsumi (1)

1 - Waseda University (Japan)

Temporal regularity is central to rhythmic perception. Previous research on auditory anisochrony discrimination has shown that sensitivity is poorer at very fast tempos, but remains stable across slower tempos. Whether a comparable temporal constraint also governs visual rhythm perception and how it compares to audition remain unclear. In the present study, we measured anisochrony discrimination in matched auditory and visual rhythms. Participants completed auditory (pure tones) and visual (brief flashes) conditions at inter-onset intervals (IOIs) of 100, 400, 1000, and 2000 ms. Each trial presented two successive four-event sequences: an isochronous standard and a comparison sequence in which either the second or third event was delayed. Participants indicated which sequence contained the temporal irregularity, and just noticeable differences (JNDs) were estimated for each IOI. Across IOIs, JNDs were consistently larger in vision than in audition, indicating lower temporal

precision for visual rhythms. Importantly, both modalities showed a non- monotonic tempo function: thresholds peaked at 100 ms, reached a minimum at intermediate IOIs, and increased again at 2000 ms. However, the detailed shape of this function differed between modalities, suggesting that a shared tempo-dependent constraint is further shaped by modality-specific timing mechanisms. An additional analysis indicated that musical training (but not general perceptual ability) was associated with the size of the audition–vision gap in JNDs, whereas neither trait reliably altered the IOI-dependent pattern. Together, the findings support a partially shared temporal architecture for rhythm perception across senses, while also highlighting modality-specific differences in temporal precision.

Poster #5.18: The superiority of musicians and video gamers for temporal information processing is not modality-specific

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**speaker*

We already know that musicians are better than non-musicians for judging the duration of time intervals. However, the question remains whether musicians would outperform individuals highly trained in another timing-dependent domain, such as video gaming. The hypothesis posited was that the response to this question may depend on the way of marking time intervals: with auditory vs. visual signals. The rationale for the hypothesis is that musicians must process rapid auditory sequences with high efficiency, just as skilled video-game players must efficiently process fast-changing visual stimuli. Groups of musicians and of video gamers were compared to a control group in time interval discrimination (standard = 600 ms; comparison intervals from 425 ms to 775 ms) and reproduction (target = 400, 500, 600,700, or 800 ms) tasks. Intervals were marked by auditory or by visual stimuli. Musicians (n=18) and gamers (n=14) outperformed participants of the control group (n=18) in precision, i.e., had a higher level of interval discrimination and lower variability in interval reproductions. The three groups did not differ in accuracy (mean reproduced intervals). The results also indicate that, in both discrimination and reproduction tasks, precision was greater when intervals were delimited by sounds rather than visual stimuli, and the precision of musicians and gamers did not differ, regardless of whether the intervals to discriminate or reproduce were marked by auditory or visual signals. The study indicates that if the superiority of musicians and gamers is due to training, this effect is not modality specific.

Poster #5.19: Temporal discrimination in augmented reality is invariant across viewing distance but sensitive to stimulus order

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Perceived time is often linked to spatial representations, yet it remains unclear whether viewing distance alters temporal judgments. We examined temporal discrimination for identical 3D objects presented at Near (60 cm) and Far (120 cm) distances across two augmented reality (AR) experiments. Participants categorized test intervals as shorter or longer than a reference interval. Performance was quantified with sensitivity (d′) and response bias, and order effects were tested by varying whether the test interval appeared before or after the reference (test–reference vs reference–test). In Experiment 1 (N = 30), viewing distance showed no reliable main effect on d′ or bias in overall models.

Pairwise comparisons suggested modest Near greater than Far differences with medium effect sizes, but Bayesian evidence favored the null, indicating weak support for consistent spatial modulation. Stimulus order significantly influenced d′, and bias showed effects of distance and order plus a distance by order interaction, suggesting that any spatial influence on decision criterion depended on sequence. In Experiment 2 (N = 30), distance again had no effect on d′, and bias showed weak, inconsistent distance effects. By contrast, stimulus order robustly modulated both d′ and bias, and bias again exhibited a significant distance by order interaction. Overall, temporal discrimination in AR was largely invariant to viewing distance, providing limited evidence that depth alone alters temporal sensitivity. Instead, sequential order consistently shaped both sensitivity and decision criterion, with spatial effects emerging primarily through order dependent comparison processes highlighting decision dynamics as key drivers of space-time effects.

Poster #5.20: Cerebral basis and temporal dynamics of the audiovisual temporal binding window: a transcranial magnetic stimulation and awake surgery study

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The temporal binding window (TBW) corresponds to the time interval within which auditory and visual stimuli are perceived as synchronous, a key principle of multisensory integration. Although neuroimaging studies have identified a distributed cortical network underlying the TBW, few have used causal methods to probe the specific regions involved and their temporal dynamics of activity. To address this gap, we combined two complementary approaches with high temporal and spatial resolution. In a first study, single-pulse MRI-guided transcranial magnetic stimulation (TMS) targeted the bilateral superior temporal gyrus (STG) and intraparietal sulcus (IPS) during an audiovisual simultaneity judgment (SJ) task in 40 healthy participants. Early stimulation of the left IPS and right STG (100-150 ms) increased perceived synchrony, whereas later stimulation of bilateral STG (~250 ms) decreased it, revealing temporally distinct contributions of parietal and temporal regions to audiovisual binding. In a second study, direct electrical stimulation (DES) was applied intraoperatively at 62 cortical sites during awake surgery in 39 patients performing the same task. DES transiently disrupted simultaneity judgments in seven focal right-hemispheric sites (<1 cm^2) around the IPS and supplementary motor area (SMA), confirming a right-lateralized frontoparietal role in audiovisual temporal integration. Together, these findings provide converging causal evidence for a distributed parieto-temporal network orchestrating audiovisual temporal binding, with a temporal dissociation between early perceptual (STG) and later decisional-attentional (IPS, SMA) stages. This dual approach refines our understanding of the neural mechanisms underlying audiovisual temporal integration and highlights its relevance in awake neurosurgery.

Poster #5.21: Rhythmic auditory stimulation affects sensitivity and bias in visual temporal order judgments

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Auditory stimulation can influence the perceived timing of concurrent visual events. Visual time perception also depends on ongoing neural oscillations, particularly around 10 Hz, which can be

entrained by rhythmic stimuli. However, little is known about the effects of rhythmic auditory stimulation on visual time perception. Here, we demonstrate that auditory rhythmic entrainment affects visual temporal order judgments (TOJ) and that this effect is selective for specific temporal frequencies. In Experiment 1, we measured TOJ for two briefly displayed horizontal bars presented after the offset of a 3-s sound amplitude-modulated at 5, 10, 15, 20, or 25 Hz, as well as in a baseline condition without auditory entrainment, in 17 participants. Auditory modulation impaired participants' ability to discriminate visual temporal order, producing a shallower psychometric function compared to baseline. The effect was absent at 25 Hz, with a clear peak at 10 Hz. In Experiment 2, we measured bias and sensitivity by densely sampling responses in the 100 to 700 ms following auditory modulation at 5 or 15 Hz to assess oscillatory behavior after entrainment. A general linear model analysis of single trials revealed that bias fluctuates periodically at a frequency that depends on the preceding auditory stimulation. These results show that auditory stimuli can influence visual time perception not only through multisensory integration, but also by interacting with the resting-state activity of the visual system prior to the presentation of a visual stimulus, likely by eliciting activity that reverberates cross-modally over a period of hundreds of milliseconds.

Poster #5.22: Modulation of sensorimotor integration in temporal order judgments

Bartolini Tommaso (1) (2), Riberto Martina (1), Vannucci Fabio (1), Campus Claudio (1), Gori Monica (1) (3)

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To interact effectively with objects in the environment, it is essential to accurately perceive the temporal relationship between voluntary actions and external sensory events. This ability relies on the temporal integration of external sensory inputs with proprioceptive signals from one's own movement. However, the extent to which cognitive processes (particularly attention) modulate this form of sensory-proprioceptive integration remains unclear. In this study, we investigated how different sensory conditions might influence precision in a temporal order judgments (TOJ) task relative to movement conclusion. 19 adult participants performed an upward movement, while holding the end effector of a robotic haptic device, until a resistive force applied by the device brought the motion to a stop. A sensory stimulus was then delivered shortly before or after this ending point, and participants judged whether it occurred before or after the movement ended. The task included three unisensory conditions (auditory, visual, tactile) and two multisensory conditions (visuo-tactile, audio-tactile). For each condition, we computed the point of subjective simultaneity (PSS) and just noticeable difference (JND). To assess attentional contributions, we correlated TOJ performance with participants' scores on the Trail Making Test B (TMT-B), a measure of divided attention. We observed a positive correlation between number of errors on the TMT-B and the JNDs in multisensory conditions (visuo- tactile: r=0.65, p=0.003; audio-tactile: r=0.67, p=0.002), indicating reduced temporal precision under increased attentional demands. These findings suggest that multisensory integration during action execution is shaped by attentional capacities and highlight the relevance of cognitive factors in temporal perception across modalities. This work of the MELD (Multisensory Environments to study Longitudinal Development) was supported by a generous unrestricted gift from Reality Labs Research, a division of Meta.

Poster #5.23: Haptic and auditory cue reliability in temporal binding during audio-haptic interactions

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Temporal binding (TB) — the subjective compression of the time between an initiating event (often a voluntary action) and its sensory consequence (often a sound) — is increasingly understood as multisensory causal integration rather than a pure marker of agency. In this view, perceived action–outcome intervals arise from the precision- weighted combination of event-time cues: when the timing of the action or outcome becomes less reliable, its contribution is down-weighted, biasing perceived timing toward the other event and increasing interval compression. Yet, despite the inherently haptic nature of most actions, the contribution of touch to TB has received surprisingly little attention. To address this gap, we systematically manipulate the reliability of haptic and auditory cues in mechanical button-press action–outcome chains using a within-subjects interval- estimation task. Across conditions, we independently reduce (1) haptic reliability of the action (intact contact vs. continuous vibrotactile masking during pressing), (2) auditory reliability of the action (mechanical click sound present vs. absent), and (3) auditory reliability of the outcome (near-threshold vs. clearly audible outcome sound). Continuous force measurement tracks pressing behavior across conditions. We hypothesize that attenuating the reliability of either the action or the outcome cue will increase TB, consistent with precision-weighted integration pulling the less certain event toward the other. Together, the study provides a systematic behavioral test of precision- weighting accounts of haptic and auditory contributions to TB, with data collection currently ongoing.

Poster #5.24

Poster #5.25

Poster #5.26: Embodying an elongated virtual arm modulates spatial effects on time perception

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Time perception is closely related to body-centered spatial representations. Stimuli presented within peripersonal space (PPS), the region surrounding the body, are perceived differently in duration from those in extrapersonal space. PPS is not fixed but flexible. Previous studies have shown that tool-use training can reduce the tendency for stimuli in far space to be perceived as longer than those in near space, suggesting that action-related spatial representations can influence time perception. However, it remains unclear whether changes in body representation through virtual embodiment can modulate the spatial influence on time perception. The present study investigated whether embodying an elongated virtual arm alters spatial effects on time perception in virtual reality. Participants performed a temporal reproduction task for visual stimuli presented in near and far space before and after an embodiment task. During the embodiment phase, participants controlled an avatar with either a normal arm or a visually elongated arm through visuo-motor synchrony. Stimulus size was manipulated to control visual angle across spatial distances, and stimulus duration was varied across

trials. We found that the effect of spatial distance on reproduced duration depended on the embodied arm length and stimulus size. For large stimuli, reproduced duration was longer for far than near stimuli in the normal-arm condition, whereas this spatial distance effect was reduced in the long-arm condition. These findings suggest that embodying an elongated virtual arm may reshape body-centered spatial representations, potentially bringing far space closer to the perceived body and thereby modulating time perception.

Computational Modelling

Poster #5.27: The hidden structure of synesthetic associations: a mixture modeling framework

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Across many forms of synesthesia, the specific associations reported by synesthetes are often described as idiosyncratic. However, large datasets reveal that certain stimuli are systematically more likely to evoke certain synesthetic associations. Numerous studies have proposed "rules" – often termed Regulatory Factors (RFs) – that link perceptual, semantic, or affective properties of a stimulus to the sensory qualities of the concurrent (synesthetic) experience it evokes. Unfortunately, studies often examine a single RF in isolation, and statistical approaches vary widely. This fragmented literature makes it difficult to compare RFs quantitatively or to understand how multiple RFs jointly influence which stimulus gets which concurrent. As a result, any one study explains only a small fraction of observed variance, making synesthetic associations appear noisy or "idiosyncratic". Here, I outline a mixture modeling approach, in which synesthetic associations result from a mixture of latent RF-specific probability distributions whose relative strengths can be estimated from behavioral data. I show three applications of this model: (1) comparing semantic and emotional mediation of touch-color associations; (2) using a linguistic "hyperparameter", orthographic depth, to explain why pronunciation influences grapheme-color associations more strongly in some languages; (3) identifying synesthetes with "subvariants" of music-color synesthesia. This framework allows RFs to be compared directly, disentangles competing predictions, and provides a principled way to interpret variation in synesthetic associations (and cross-modal correspondences more broadly) as meaningful signal rather than unexplained noise.

Poster #5.28: Predicting the magnitude and direction of kinesthetic illusions: a novel computational approach

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Proprioception is essential for motor control. Muscle spindles encode magnitude and velocity of changes in muscle length. Tendon vibration provides a controlled method to selectively activate muscle spindles, as denoted by the resulting vivid illusions of limb movements. However, the mechanisms underlying position perception and their potential for neurorehabilitation applications require further investigation. Here, we used tendon vibration to quantify how muscle spindles can reliably predict the perceived final hand position after vibrating biceps and triceps tendons. Fifteen healthy subjects (24-45 years) were asked to report the hand position perceived after tendon vibration

on a 9x21 A3 grid. The right arm rested on a table, with the elbow angle set at 90°, and occluded from view by an upper platform. Custom vibrators delivered 90 Hz stimulation to the biceps and/or triceps tendons using 11 patterns across three durations (1, 3, 6 s), applied in isolation, simultaneously, or sequentially. After each stimulation, participants verbally reported the illusion-induced new coordinates of their index finger on the grid and the vividness of the illusion. Each pattern was repeated three times. A data-driven approach was used to model the relation between vibration duration and elbow joint angle for each muscle separately. The slope of the obtained linear regressions was used to predict the joint angle perceived through more complex stimulation patterns. Despite the variability in the elbow joint angle vs. stimulation duration relation across subjects, the model could produce good predictions. This model could be applied to provide proprioceptive inputs for new-generation hand prostheses.

Poster #5.29: Merging spatial exploration and multisensory research: introduction of sp.ex

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Spatial exploration abilities are fundamental to support optimal development but are generally quantified using metrics that may mischaracterize exploratory patterns and fail to capture critical aspects environmental probing. Therefore, we developed sp.ex, a novel, parameter-less method to quantify spatial exploration in any bounded environment. Here, we applied sp.ex to a real-world scenario involving children with visual impairments (VI), evaluating its performance against other metrics. Six children with peripheral low vision were recruited from the center of child neuro-ophthalmology, Mondino (Pavia). Children played freely for 5 minutes without sensory cues, defining the baseline (B), and 5 minutes where multisensory (MS) cues (audio-visual) were delivered via small customized devices (TechARMS) placed randomly in the space, prompting children to locate them as quickly as possible. Children's motion was tracked via a 3D motion capture system. By fitting four GLMM, we tested whether sp.ex, area covered by trajectories (BBA), path lengths (PL), and distances from points of interest (dPOI) predicted if trials belonged to the MS or B conditions. Between-individual variability was negligible, reducing models to simple logistic regressions. Only sp.ex ($p=0.02$) and BBA ($p=0.01$) significantly predicted the MS condition, showing that to higher values of sp.ex or BBA it increased the likelihood that a trial came from the MS condition rather than the B ($\beta = 0.71$ and $\beta = 0.80$, respectively). Overall, sp.ex and BBA emerged as the most sensitive indicators of increased exploration under multisensory stimulation, demonstrating sp.ex utility as a robust and informative metric for characterizing spatial behavior in VI children. Figure summary: (A) Violin plots showing the distribution of sp.ex and BBA for the sensory conditions. Both me trics indicate increased spatial exploration with MS. (B) Receiver Operating Characteristic (ROC) curves co mparing the ability of sp.ex, BBA, PL, dPOI to discriminate MS from B trials. Sp.ex and BBA demonstrate the hig hest discriminative performance. (C) Example heatmaps one participant in each condition. Warmer (red) areas indicate regions of higher spatial occupancy. The sp.ex values for each trajectory are displayed above the maps, illustrating low exploration during the baseline condition and markedly increased exploration under multisensory stimulation.

Poster #5.30: Multisensory cueing reflects earlier attentional orienting rather than attentional gain

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Individuals typically detect and discriminate multisensory signals faster than unisensory signals. When acting as cues, multisensory signals can orient attention earlier than unisensory cues, producing a transient orienting advantage. This effect has been observed particularly at short cue–target onset asynchronies (CTOAs; ~50 ms). However, the mechanism underlying this behavioural advantage remains unclear. One possibility is that multisensory cues accelerate the deployment of spatial attention, initiating orienting earlier in time. Alternatively, multisensory signals may increase attentional gain at attended locations, enhancing the quality of evidence accumulated during decision formation. To dissociate these possibilities, we examined multisensory exogenous orienting using drift diffusion modelling (DDM). Participants performed a speeded visual orientation discrimination task following spatially non-predictive cues that were unimodal (visual), crossmodal (auditory), or bimodal (audiovisual). Cue validity (valid vs. invalid) was manipulated by varying the spatial correspondence between cue and target. Reaction time and accuracy distributions were fitted using DDM to estimate latent decision parameters, including drift rate (v) and non-decision time (Ter). Bimodal cues produced larger response time cueing benefits than unimodal or crossmodal cues. DDM parameter estimates indicated that this advantage was primarily explained by reductions in non-decision time rather than increases in drift rate. These findings suggest that multisensory cues facilitate earlier attentional orienting rather than enhancing the strength of sensory evidence during decision formation. The results provide computational evidence that multisensory orienting advantages arise from earlier attentional orienting rather than increased attentional gain resulting in increased evidence accumulation.

Poster #5.31: Artificial multisensoriality and responsibility: regulatory and philosophical implications of multimodal integration in the era of the ai act

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The rapid expansion of multimodal artificial intelligence systems—capable of integrating visual, auditory, tactile, and physiological data—poses significant regulatory challenges that extend well beyond the traditional boundaries of technology governance. While multisensory integration has long been examined as a core feature of human cognition, its artificial implementation introduces complex issues related to transparency, accountability, risk management, and the lawful processing of heterogeneous data streams. This contribution focuses primarily on the legal and compliance implications of artificial multisensoriality in light of the European Union's AI Act, which enters into full application in 2026 and directly regulates high-risk AI systems, including those relying on multimodal data processing. From a regulatory standpoint, multimodal architectures challenge existing compliance frameworks due to the opacity of their integration mechanisms, the potential propagation of cross-modal biases, and the difficulty of establishing clear responsibility chains across interconnected datasets and algorithmic components. The AI Act provides a structured set of obligations—covering risk assessment, data governance, human oversight, technical documentation, and post-market monitoring—that constitute the first comprehensive regulatory framework for such systems. However, when applied to multisensory AI, these obligations reveal gaps concerning verifiability of integration processes, auditability of cross-modal interactions, and the traceability of

decision-making pathways. This work proposes a compliance-by-design model specifically tailored to multimodal systems, emphasizing robust documentation of integration logic, systematic cross-modal bias auditing, and enhanced transparency measures to support both regulatory scrutiny and user trust. While philosophical considerations remain relevant for understanding the conceptual divergence between human and artificial multisensoriality, they serve here primarily to contextualize the normative need for accountability and interpretability. By integrating legal, regulatory, and technological perspectives, this contribution outlines a framework for responsible artificial multisensoriality aligned with the emerging European governance landscape.

Poster #5.32

Poster #5.33: From streams to scenes: a computational account of audiovisual binding and segregation

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To form a coherent percept of the environment, the brain must integrate sensory signals that share a common cause while segregating those that arise from different sources. How within and cross modal binding cues jointly influence causal inference in complex audiovisual scenes remains unclear. We recently addressed this using an ambiguous scene in which human observers heard alternating high and low pitched tones presented from the center, either alone or synchronized with flashes appearing alternately in the left and right hemifields. We manipulated inter flash distance, a visual binding cue, that exerted a striking non monotonic influence on auditory perception: small distances enhanced audiovisual integration, intermediate distances promoted segregation, and large distances produced little effect because flashes were too far apart to bind. To explain this multisensory interaction, we developed a computational model building on a recent non parametric Bayesian framework for auditory streaming (Larigaldie et al., 2025). The model assumes that the brain groups auditory signals into latent streams while minimizing representational complexity, and extends this principle to audiovisual stimuli through Bayesian causal inference. When fit to behavioural data, the model provided an good account of observers' responses (r^2 = 0.78). Qualitative and quantitative comparisons with competing models will be presented. These findings demonstrate how the brain combines multiple binding cues to infer causal structure in complex audiovisual scenes and outline a principled computational mechanism for assigning sensory signals to their sources.

Poster #5.34: Benefits and challenges of large-n vs small-n approaches in multisensory cue combination studies

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Measuring increases in perceptual precision is crucial for determining whether two sensory cues are combined into a single percept. While changes in accuracy/perceptual biases can also be explained by cue switching, precision increases are widely recognised as a signature of integration. However, determining precision changes experimentally is not straightforward: measurement protocols are

strict (Rohde et al., 2016) and possible effect sizes are small (Scarfe, 2023; Scheller & Nardini, 2024), requiring larger samples than those most previous studies included. What is more, recent studies that systematically assessed combination with familiar and novel cues found stable, individual differences in cue combination (Scheller et al., 2026), which may dilute the already small effects even more in group-level analyses. In contrast, small-n approaches (Smith & Little, 2018) can offer meaningful ways to determine precision changes at the individual level. However, to balance measurement noise with small effects sizes, small-n designs need to be adapted to ensure individual-level statistical reliability. Here, we present steps for implementing small-n designs to measure cue combination at the individual level. Using our own recent large-n and small-n studies as examples, we highlight the needs for: (1) large numbers of trials; (2) design efficiency: continuous designs over 2AFC; (3) stimulus space optimization: calibrating single cues; (4) parameter estimation efficiency enhancement: hierarchical models comparing parameters within participants, (5) and simulation-based inference criteria. Together, these steps allow to draw meaningful inferences about cue combination at the individual level and better characterise multisensory combination in situations in which there is considerable individual variability.

Poster #5.35: What's in a model? Assumptions, scope, and explanatory power in multisensory research

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Over the last three decades, multisensory research has evolved from a niche area within perception science into a fully established discipline. As new multisensory phenomena and perceptual illusions have been discovered, a range of theoretical models has been developed to account quantitatively for this expanding body of work. These models, however, were often designed with different aims: some seek to explain neurophysiological responses to bimodal stimulation, whereas others focus on the behavioural costs and benefits associated with concurrent inputs across sensory modalities. Ideally, a perceptual model should capture the full processing pipeline, from stimulus transduction to the generation of behavioural and neurophysiological responses, while relying on a minimal set of plausible assumptions. In this presentation, I will map the theoretical landscape of multisensory research and evaluate the extent to which current models approach this ideal, as well as whether their core assumptions are empirically and conceptually justified.

Poster #5.36: When stronger meets sooner: joint effects of signal intensity and timing on multisensory responses

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Thomas U. Otto The benefits of multisensory integration can be studied through the redundant signals effect (RSE), whereby responses are, on average, faster to multisensory compared to unisensory signals. The race model accounts for this effect by proposing parallel processing of signals, with responses triggered by the faster modality on a given trial. According to the principle of equal effectiveness (PoEE), the RSE is largest when unisensory reaction times (RTs) are similar, allowing modalities to effectively "race" each other. Thus, when unisensory RTs are unequal, the signal in the faster modality must be delayed by an interval approximating the unisensory RT difference to maximise the RSE. This prediction can be tested using manipulations of signal intensity and stimulus

onset asynchrony (SOA). However, prior research has predominantly examined conditions in which auditory RTs are equal to or faster than visual RTs, restricting tests of the PoEE to cases of auditory dominance. To address this gap, we manipulated signal intensity in a 2x2 design, yielding four audio-visual signal strength combinations. These manipulations were highly effective, producing RT differences of up to 200ms between low and high intensity signals. We then tested each intensity combination across nine SOAs to determine the temporal onset that maximises the RSE. Critically, when visual signal was of higher intensity, the largest RSE was observed at SOAs involving delays of the visual signal. These findings demonstrate that the RSE conforms to the PoEE in both directions, thus supporting the generality of race model predictions under conditions of reversed modality dominance. 249 words

Poster #5.37: A combined modelling approach to explain the neural dynamics and the temporal constraints responsible for the sound-induced flash illusion

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The sound-induced flash illusion (SIFI) refers to the observation that pairing a single flash with 2 auditory beeps leads to the illusory perception of 2 visual stimuli (fission illusion). Susceptibility to the illusion depends on many factors like exact physical stimulus parameters, participants` expectations, attention, age, and clinical/non-clinical population membership. While there exist many experimental studies, very few models have been proposed to account for the phenomenon. Here we analyze the illusion combining two modelling perspectives: the "Time-Window-of-Integration for SIFI" model based on the cognitive notion of a temporal binding window, and the "Multisensory Integration with Crossed Inhibitory Dynamics" (MICID) model, a biologically plausible neural network, implementing a theoretical framework for the audio-visual interactions and integration. The first, postulating a specific temporal arrangement of sensory processes triggered by the occurrence of beeps and flashes, predicts the frequency of illusory flashes. The second reveals the corresponding neural network structure and puts it within the Bayesian Causal Inference explanation of the illusion. Moreover, it suggests the synaptic mechanisms responsible for the temporal binding window and explains the inputs' temporal constraints to elicit the illusion. The strength of this combined modelling approach is illustrated on a study investigating differences in SIFI performance between elderly hearing aid users and those with the same degree of mild hearing loss who were not using hearing aids. The two models will help to better understand and explain the diverse results from clinical and non-clinical studies.

Poster #5.38: The McGurk effect in congenital and acquired low vision

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In neurotypical development, the mechanism of cross-modal integration of visual and auditory information matures until adolescence. In cases of congenital or acquired visual impairments, the integration processes underlying bimodal perception might be critically hindered. To investigate the effect of visual impairments on auditory-visual fusion during speech perception, we performed a McGurk test in a group of adults and adolescents with congenital or acquired visual impairments, and in a control group of sighted subjects (tested under blurred and unblurred visual conditions). As expected, in the blurred condition, sighted individuals showed a reduced McGurk effect (i.e. audio-visual fusion in presence of incongruent audio-visual stimuli), with auditory dominance in the remaining trials. Conversely, subjects with low vision mainly showed auditory dominance and no McGurk effect. However, when the McGurk effect was present, we found an interesting trend of visual dominance, which is absent in subjects with normal vision. We hypothesize that such a visual dominance could be a consequence of congenital visual disorders hindering the development of the capability to correctly integrate the two sensory modalities, which is instead already acquired in case of visual impairments occurring later in life. We used a computational model to predict the mechanism of neural integration for stimuli encoded in visual and auditory brain regions, and to explain the empirical results as a consequence of either an altered visual stimulus or an altered connectivity pattern between sensory and associative brain areas, for acquired and congenital visual disorders, respectively.

NETWORKING WORKSHOPS

NETWORKING WORKSHOP 1

JUNE 25th | 6:30 pm – 7:45 pm

SCIROCCO ROOM

Improv-based tips for researchers

Zanchi Silvia (1)

1 - Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia (Italy)

Discover how key principles of improv theatre, such as adaptability, active listening, and creative collaboration, can support researchers in navigating uncertainty, strengthening teamwork, and enhancing academic communication and presentation skills.

NETWORKING WORKSHOP 2

JUNE 25th | 6:30 pm – 7:45 pm

PONENTE ROOM

Painting sensory modalities

Gori Monica (1)

1 - Unit for Visually Impaired People (U-VIP), Istituto Italiano di Tecnologia (Italy)

Explore fundamental principles of color techniques and examine how different sensory experiences, such as sound, touch, or emotion, can be translated into artistic expression through color. Participants will be guided to experiment with color as a tool for perception, interpretation, and creative communication.