PROGRAM

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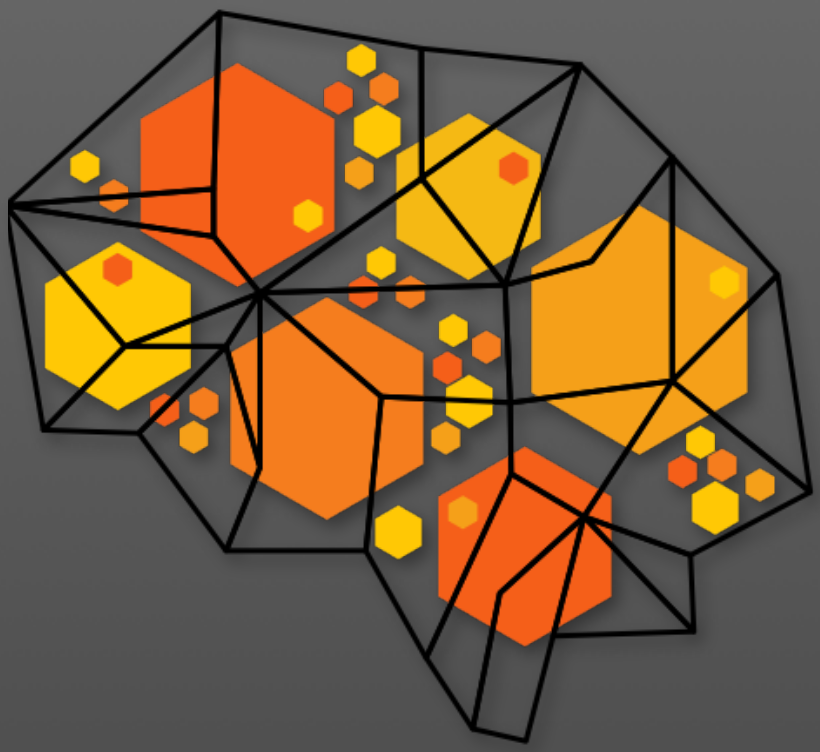
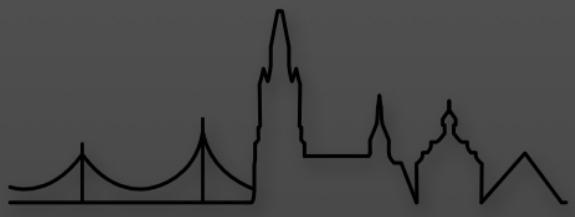
International Multisensory Research Forum





ULM 2022

July 4-7

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International Multisensory Research Forum

ULM 2022

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International Multisensory Research Forum

ULM 2022

	04.07.		05.07.		06.07.		07.07.	
	Room Danube	Room Lago	Room Danube	Room Lago	Room Danube	Room Lago	Room Danube	Room Lago
8:30								
8:45			**Session 1:** Multisensory Recalbiration	Posters on display 2 & 3	**Session 5:** Multisensory Concepts	Posters on display 4 & 5	**Session 9:** Body / Action	**Session 10:** Tactile
9:00								
9:15					**Spotlight Talk:** D. Maurer			
9:30								
9:45			**Break**		**Break**		**Break**	
10:00	Registration							
10:15			**Session 2:** Atypical / Deprivation	Posters on display 2 & 3	**Session 6:** Chemical & Pain	Posters on display 4 & 5	**Symposium 7:** Multisensory Processing in Autism	**Symposium 8:** Neural Modelling of Multisensory Integration
10:30								
10:45								
11:00								
11:15							**Break**	
11:30								
11:45			**Poster Session 2**		**Poster Session 4**		**Symposium 9:** Deafness and blindness as insights into cognition	**Symposium 10:** The non-veridical perception of touch
12:00	**Opening Remakrs**							
12:15								
12:30	**Symposium 1:** Multisensory development: localisation, learning and sensory loss	**Symposium 2:** Auditory influences on low-level vision	**Lunch**		**Lunch**			
12:45								
13:00								
13:15								
13:30	**Break**						**Closing & Business Meeting**	
13:45								
14:00								
14:15	**Symposium 3:** Dynamics and rehabilitative power of multisensory plasticity	**Symposium 4:** Twenty years of the Sound Induced Flash Illusion: What have we learnt?	**Session 3:** The Multisensory Brain	Posters on display 2 & 3	**Session 7:** Multisensory Development	Posters on display 4 & 5		
14:30								
14:45								
15:00								
15:15			**Break**		**Break**			
15:30	**Break**							
15:45								
16:00								
16:15	**Symposium 5:** (A)typical Multisensory Processing	**Symposium 6:** New insights on multi-sensory brain organization from MVPA to high field fMRI	**Session 4:** Time, Space and Motion	Posters on display 2 & 3	**Session 8:** Vestibular / Self-Motion	Posters on display 4 & 5		
16:30								
16:45								
17:00			**Poster Session 3**		**Poster Session 5**			
17:15	**Break**							
17:30								
17:45	**Keynote 1:** **Burr:** The *number sense*: generalized across space, time, sensory modality, and action		**Keynote 2:** **Grothe:** The Spatial Representations of Sounds		**Keynote 3:** **Schmidt:** Interacting with Intelligent Systems			
18:00								
18:15								
18:30								
18:45								
19:00	**Poster Session 1**		**Leisure Time**		**Conference Dinner (open end)**			
19:15								
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20:45	**Reception**							
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PROGRAM

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International Multisensory Research Forum

ULM 2022

Keynotes

Monday Keynote

5:45pm - 7:00pm

Room Danube

The *number sense*: generalized across space, time, sensory modality, and action

Burr, David, University of Florence

Abstract: Humans and other animals can estimate rapidly the number of items in a scene, flashes or tones in a sequence and motor actions. Adaptation techniques provide clear evidence in humans for the existence of specialized numerosity mechanisms that make up the numbersense. This sense of number is truly general, encoding the numerosity of both spatial arrays and sequential sets, in vision and audition, and interacting strongly with action. The adaptation (cross-sensory and cross-format) acts on sensory mechanisms rather than decisional processes, pointing to a truly general sense.

Bio: David Burr is a world-class leader in visual neuroscience. For most of his career he has worked on human vision, although hehas more recently ventured into touch, audition,multi-sensory researchand perceptual decision-making. His research approach is fundamentally multidisciplinary, embracing classical psychophysics, animal electrophysiology, human physiology –including evoked potentials,functional imagingand clinical studies –and computational modelling. He has made major contributions to most areas in sensoryneuroscience, including the perception of space, time, motion, eye-movements, colour,and number–and their development.

Tuesday Keynote

5:45pm - 7:00pm

Room Danube

The spatial representations of sounds - A journey through time and along the auditory pathway

Grothe, Benedikt; Max Planck Institute of Neurobiology, Germany;

Abstract: The perception of a sound's spatial location must be computed and processed entirely within the brain, as space is not mapped onto the auditory epithelium. Interestingly, and in contrast to birds, mammals compute no topographical map of space along the early canonical auditory hierarchy. It, is, however, still debated how auditory space is neuronally represented at higher levels of the mammalian auditory system. On the one hand, the two-channel hypothesis is primarily based on auditory brainstem studies and states that in mammals, spatial information is not encoded via labeled-line projections as in the bird brainstem but rather encoded in the general firing rates of large, opposing, hemispheric channels. On the other hand, there is circumstantial evidence for cortical neurons responding to frontal locations only as well as human EEG studies postulating a third (central) channel. To investigate this apparent contradiction, we employed repeated two-photon calcium imaging in the AC of awake and anesthetized mice and probed the spatial tuning of the same hundreds of neurons over weeks. We found that evoked responses were generally stronger under awake conditions (consistent with previous studies), but also that spatial tuning toward the front of the animal was specifically suppressed under anesthesia. Spatial tuning of individual neurons changed from session to session, but the population as a whole remained predominantly stable. These findings indicate that the information from the two ears is initially contrasted in the brainstem into a two-channel system which, at the level of the cortex is then differentiated into a dynamic representation of all positions in space. This raises specific question how visual and auditory information can be neuronally aligned to a coherent perception of space.

Bio: Prof. Dr. Benedikt Grothe is Chair of Neurobiology at the Ludwig-Maximilians-Universität München (LMU) and fellow of the Fellow of the Max Planck Society. He studied Biology and conducted a PhD in Munich at the LMU. Between 1991 and 1993 he did a postdoc at the University of Texas at Austin with George D. Police and a postdoc at the New York University, Center for Neural Sciences with Dan. H. Sanes. 1994 He became Assistent Professor at the LMU and in 1999 research Group Leader at the MPI Neurobiology in Martinsried. Since 2003 he is Professor of Neurobiology at he LMU.

Wednesday Keynote

5:45pm - 7:00pm

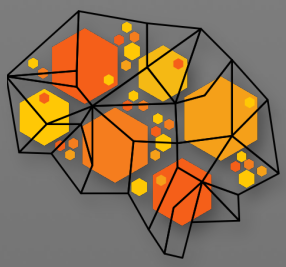
Room Danube

Interacting with Intelligent Systems: Human-AI Collaboration to Amplify Human Abilities

Schmidt, Albrecht; Ludwig-Maximilians-Universität München, Germany;

Abstract. The use and development of tools are strongly linked to human evolution and intelligence. Physical tools, from the wheel to the plane and from knifes to production machines, have transformed what people can do and how people live. Currently, we are at the beginning of an even more fundamental transformation fueled by artificial intelligence and autonomous systems: digital tools, with built-in intelligence to amplify human abilities. Such digital technologies will provide us with entirely new opportunities to (1) enhance the perceptual and cognitive abilities of humans and (2) to delegate intermediate decisions and to interact on a different level of granularity. In our research we create novel digital technologies to systematically and empirically explore how to enhance human abilities. We aim to create an efficient and pleasant cooperation between (embodied) intelligent systems driven by artificial intelligence and human actors. If such a cooperation is successful, the resulting human-technology-system will outperform the technical system as well as the human user. It is exciting to see how ultimately these new ubiquitous computing technologies have the potential for making human actors more powerful. The vision is to overcome fundamental limitations in human perception, action, and cognition and eventually create abilities, currently considered as super powers. But this vision will come at a price, we delegate control and strive towards highly optimized systems – that apparently work great for the user, but at the same time may end the element of randomness and serendipity in our lives. This opens the question if interactive human centered artificial intelligence can help to keep the user in control or if this is just an illusion.

Bio. Albrecht Schmidt is a professor of computer science at Ludwig-Maximilians-Universität (LMU) in Munich, where he holds a chair for Human-Centered Ubiquitous Media, a co-founder of ThingOS GmbH, and the scientific co-director of the Center for Digital Technology and Management (CDTM). His teaching and research interests are in human-centered artificial intelligence, intelligent interactive systems, ubiquitous computing, multimodal user interfaces, and digital media technologies. He studied computer science at the University of Ulm (Germany) and at the Manchester Metropolitan University. In 2003 he completed his PhD on the topic of "Ubiquitous Computing - Computing in Context" at Lancaster University. Albrecht chaired the technical program of ACM SIGCHI 2014, he is on the editorial board of the ACM TOCHI journal, and he is the cofounder of the ACM conference TEI and Automotive User interfaces. In 2018, he was inducted into the ACM SIGCHI Academy and in 2020; he was elected into Leopoldina, the Germany academy of science.



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International Multisensory Research Forum

ULM 2022

Monday Afternoon Talks

12:00pm – IMRF Opening

12:15pm – 1:30pm

Room Danube

Multisensory development: localisation, learning and sensory loss

Chair(s): **Dewe, Hayley L., Cowie, Dorothy**

Orienting responses to tactile and auditory stimuli on the hands in sighted and blind infants.
Bremner, Andrew J., Campus, Claudio, Tonelli, Alessia, Signorini, Sabrina, Gori, Monica;

Memory and sounds: the effect of early visual deprivation on mnestic skills in blind kids.
Setti, Walter, Cuturi, Luigi F., Gori, Monica;

Visuotactile and visuomotor synchronicity in the developing sense of self.
Cowie, Dorothy, Dewe, Hayley L., Bird, Laura-Ashleigh, Brenton, Harry, Gillies, Marco;

The bodily self: visuomotor synchrony of virtual whole bodies in children and adults.
Dewe, Hayley L, Sill, Oscar, Kentridge, Robert, Cowie, Dorothy;

Multisensory benefits with new sensory skills.
Nardini, Marko, Negen, James, Thaler, Lore;

Room Lago

Auditory influences on low-level vision

Chair(s): **Störmer, Viola**

Visual cortex responds to transient sound changes without encoding complex auditory dynamics
Ahn, EunSeon, Brang, David;

Sound-induced activation of the occipital cortex enhances visual perception
Störmer, Viola;

Low-level supramodal activation of sensory cortices during complex spatial and temporal tasks
Amadeo, Maria Bianca, Campus, Claudio, Gori, Monica;

Time course and specificity of crossmodal prediction in visual cortex
Stange, Liesa, Ossandón, José, Röder, Brigitte;

Multisensory plasticity supporting vision rehabilitation
Murray, Micah M.;

1:30pm – 2:00pm

Break

2:00pm – 3:30pm

Room Danube

On the dynamics and rehabilitative power of multisensory plasticity.

Chair(s): **Van der Stoep, Nathan, Rowland, Benjamin;**

Using multisensory training to restore sight in the blind
Rowland, Benjamin, Stein, Barry;

Disruption and restoration of multisensory integration after mild acute asymmetric hearing loss
Van der Stoep, Nathan, Böing, Sanne, Van der Stigchel, Stefan, Versnel, Huib, Wallace, Mark;

Development of multisensory integration, visuomotor recalibration, and auditory space perception in cataract-treated individuals
Senna, Irene, Piller, Sophia, Ernst, Marc;

Visual and crossmodal activation after sight restoration in humans.
Röder, Brigitte, Dormal, Guilia, Sourav, Suddha, Shareef, Idris, Rajendran, Siddhart, Kekunnaya, Ramesh, Pitchaimuthu, Kabilan;

Hearing the visual rhythm and seeing the audio space: early cortical sensory responses in typical but not in blind and deaf individuals
Gori, Monica, Amadeo, Maria Bianca, Bertonati, Giorgia, Pavani, Francesco, Campus, Claudio;

Individual differences of brain plasticity in early visual deprivation and sight restoration
Striem-Amit, Ella;

Room Lago

Twenty years of the Sound Induced Flash Illusion: What have we learnt?

Chair(s): **Hirst, Rebecca J, Setti, Annalisa, Newell, Fiona N**

[video] Sound-induced Flash Illusion as an Example of Crossmodal Interactions in Perception
Shams, Ladan;

Solving the binding problem in the sound-induced flash illusion: computations and neural mechanisms
Noppeney, Uta;

The neural basis of the Sound-Induced Flash Illusion
Keil, Julian;

The fission and fusion illusions compared across modalities and development
Shore, David I, Chen, Yi-Chuan, Stanley, Brendan M, Lewis, Terri L, Maurer, Daphne;

The Sound-Induced Flash Illusion in The Irish Longitudinal Study on Ageing: Links with cognitive performance
Hirst, Rebecca J, Setti, Annalisa, Kenny, Rose Anne, Newell, Fiona N;

Double Flash Illusion as a tool to investigate the abnormal temporal dynamics of multisensory processing in schizophrenia and schizotypy
Ferri, Francesca, Costantini, Marcello, Romei, Vincenzo;

3:30pm – 4:00pm

Break

4:00pm – 5:15pm

Room Danube

(A)typical Multisensory Processing: from Bodily Self-Consciousness to Social Interactions

Chair(s): **Gillmeister, Helge, Auvray, Malika**

Juggling self-centred and other-centred perspectives: influence of sensory deficits and social cognition
Auvray, Malika;

Neural correlates of multisensory and visual only finger stretching: implications for treatments of chronic pain.
Preston, Catherine;

Electrophysiological studies of multisensory and emotional body perception in Depersonalisation
Gillmeister, Helge;

Disturbed cognitive and multisensory interoceptive processing in Eating Disorders: Evidence from a Bayesian meta-analysis of fMRI studies
Klabunde, Megan;

Disruptions of sensorimotor experiences and bodily self-consciousness after right hemisphere stroke
Kirsch, Louise;

Room Lago

New insights on multisensory brain organization from MVPA to high field fMRI

Chair(s): **Gaglianese, Anna, Murray, Micah M.**

Distinct sensory representations in supramodal networks: Topographic maps representing haptic numerosity
Hoffstetter, Shir, Cai, Yuxuan, Harvey, Ben M., Dumoulin, Serge O.;

Impact of blindness onset on the representation of sound categories in occipital and temporal cortices
Mattioni, Stefania, Collignon, Olivier;

Voxel-wise modelling reveals sound envelope representation in primary visual cortex
Setti, Francesca, Handjaras, Giacomo, Bottari, Davide, Leo, Andrea, Diano, Matteo, Bruno, Valentina, Tinti, Carla, Cecchetti, Luca, Garbarini, Francesca, Pietrini, Pietro, Ricciardi, Emiliano;

Auditory enhancement of visual completion
Gaglianese, Anna, Murray, Micah;

[video] Re-discovering the lost medial wall Penfield homunculus and a novel homunculus in the insula: putative multisensory links between body and mind?
Zeharia, Noa, Hoffstetter, Shir, Flash, Tamara, Amedi, Amir;

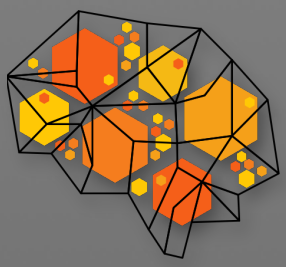
5:15pm – 5:45pm

Break

5:45pm – 7:00pm

Keynote 1: David Burr

The *number sense*:
generalized across space, time, sensory modality, and action



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International Multisensory Research Forum

ULM 2022

Monday Evening Posters

Foyer

7:00pm - 8:30pm

F1) A new Virtual Reality based paradigm to test sensory-motor plasticity in multisensory interactions
Girondini, Matteo; Montanaro, Massimo; Gallace, Alberto

F2) A combined neurophysiological and neuroimaging approach to explore the cortico-brainstem interaction in multiple sclerosis.
Biggio, Monica; Bonzano, Laura; Brichetto, Giampaolo; Bove, Marco

F3) Intermodal attention influences early somatosensory processing in the human spinal cord
Amin, Mohammed Istiaque; Azañón, Elena; Deliano, Matthias; Eimer, Martin; Stenner, Max-Philipp

F4) Neural speech tracking in the absence of visual input: Dark listening
Bednaya, Evgenia; Mirkovic, Bojana; Berto, Martina; Ricciardi, Emiliano; Martinelli, Alice; Federici, Alessandra; Debener, Stefan; Bottari, Davide

F5) Some historical data on multisensory processes
Gonzalo-Fonrodona, Isabel; Porras, Miguel A.

F6) Managing Motion Sickness in Head-Mounted VR
Jin, Christina Yi; van Wassenhove, Virginie

F7) Visual experience affects context dependency mechanisms in auditory distance estimation
Tonelli, Alessia; Mazzola, Carlo; Sciutti, Alessandra; Gori, Monica

F8) Auditory–tactile Simultaneity Perception in Adults Treated for Bilateral Congenital Cataracts
Stanley, Brendan M; Chen, Yi-Chuan; Lewis, Terri L; Maurer, Daphne; Shore, David I

F9) Cross-condition comparison of self-reported multi-sensory experience
Powell, Georgie; Sumner, Petroc; Ghaiwal, Abhay; Griffin, Charlotte; Price, Alice

F10) Fluctuation of sensory thresholds over 27 days: An eight subject study in migraine
Ikumi, Nara; Marti-Marca, Angela; Vilà-Balló, Adrià; Cerdà-Company, Xim; Torre-Suñe, Anna; Alpuente, Alicia; Caronna, Edoardo; Pozo-Rosich, Patricia

F11) How blurry are echoes? Quantifying the spatial resolution of echoic object perception
Teng, Santani; Ezeana, Michael; Puri, Amrita

F12) Reading abilities in Deaf: Role of Fovea and Parafovea
Kamble, Veena; Scaltritti, Michele; Crollen, Virginie

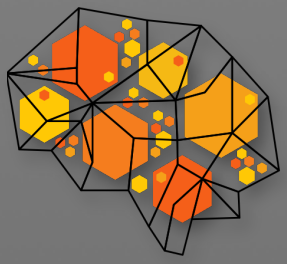
F13) The neural correlates of canonical versus non-canonical finger-number configurations in deaf, hearing signer and hearing control adults
Buyle, Margot; Lochy, Aliette; Vencato, Valentina; Crollen, Virginie

F14) Visual Field Dependence of Crossmodal Interactions in Those with Low Vision
Tanguay Jr., Armand R.; Stiles, Noelle R. B.; Ganguly, Ishani; Shimojo, Shinsuke

F15) Neural processing underlying spoken and signed language learning: an fMRI study
Alotaibi, Sahal; Meyer, Georg; Wuerger, Sophie

[withdrawn] Causal role of visual and motor cortices in the auditory translation of foreign language vocabulary following multisensory learning
Mathias, Brian; Sureth, Leona; Klingebiel, Andrea; Hartwigsen, Gesa; Macedonia, Manuela; Mayer, Katja; von Kriegstein, Katharina

F17) Crossmodal learning of target-context associations
Chen, Siyi; Müller, Hermann; Geyer, Thomas; Shi, Zhuanghua



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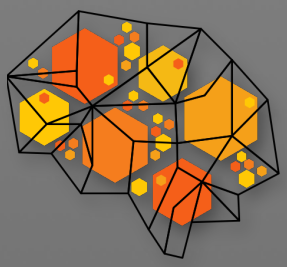
International Multisensory Research Forum

ULM 2022

Tuesday Morning Talks

	Room Danube	Room Lago
8:30am - 9:45am	**Multisensory Recalibration** *Chair:* David Burr 8:30am - 8:45am free - has been moved to Keynote 1 8:45am - 9:00am Audiovisual spatial integration and recalibration after sight restoration in humans Bruns, Patrick; Li, Lux; Guerreiro, Maria J. S.; Shareef, Idris; Rajendran, Siddhart S.; Pitchaimuthu, Kabilan; Kekunnaya, Ramesh; Röder, Brigitte 9:00am - 9:15am System identification reveals multiple interacting states responsible for visuomotor adaptation Balestrucci, Priscilla; Ernst, Marc O. 9:15am - 9:30am Judgments of agency and simultaneity following sensorimotor temporal recalibration Arikan, Belkis Ezgi; Fiehler, Katja 9:30am - 9:45am The importance of causal-inference for audiovisual spatial recalibration Landy, Michael S.; Hong, Fangfang; Badde, Stephanie	Posters on Display
9:45am - 10:15am	Break	
10:15am - 11:15am	**Atypical/Deprivation** *Chair:* Jean Vroomen 10:15am - 10:30am 'Color' Conveyed to the Blind as Timbre Through Sensory Substitution Activates Areas Correlated With Color Maimon, Amber; Yizhar, Or; Amedi, Amir 10:30am - 10:45am Decoding natural sounds in early "visual" cortex of congenitally blind individuals Vetter, Petra; Bola, Łukasz; Reich, Lior; Bennett, Matthew; Muckli, Lars; Amedi, Amir 10:45am - 11:00am Predictive coding in autism spectrum disorders: electrophysiological alterations in early auditory predictive processing as potential markers for autistic symptomatology van Laarhoven, Thijs; Stekelenburg, Jeroen; Eussen, Mart; Vroomen, Jean 11:00am - 11:15am [video] Crossmodal Correspondences in Argus II Retinal Prosthesis Patients: Leveraging Auditory-Visual Interactions to Enhance Prosthesis Outcomes Stiles, Noelle; Patel, Vivek; Weiland, James	Posters on Display
11:15am - 12:15pm		Poster Session 2



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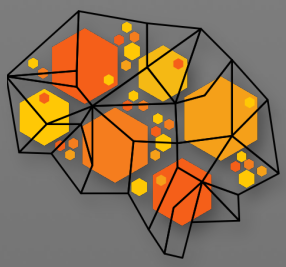
Tuesday Morning Posters

	Foyer	Room Lago
11:15am - 12:15pm	**F1) The macaque posterior cingulate gyrus: a multisensory structure** VITTEK, Anne-Laure; JUAN, Cécile; GAILLARD, Corentin; MERCIER, Manuel; NOWAK, Lionel G.; GIRARD, Pascal; BEN HAMED, Suliann; CAPPE, Céline	**L1) Auditory Spatial Cueing Improves Visual Target Discrimination Performance in Virtual Reality** Alwashmi, Kholoud; Meyer, Georg; Rowe, Fiona; Ward, Ryan
	F3) A temporally correlated visual signal improves the neural representation of an auditory object Nidiffer, Aaron R; Lalor, Edmund C	**L3) Geometry intuitions without vision? A study in blind children and adults** Marlair, Cathy; Pierret, Elisa; Crollen, Virginie
	F5) Decoding acoustic and visual features of continuous speech from EEG in children and adults. Fantoni, Marta; Federici, Alessandra; Campogonara, Ivan; Ricciardi, Emiliano; Martinelli, Alice; Nava, Elena; Bednaya, Evgenia; Bottari, Davide	**L5) Learning a new class of multisensory associations: high-density electrophysiological mapping of the temporal course of audio-visual object processing** Vercillo, Tiziana; Freedman, Edward G.; Molholm, Sophie; Foxe, John J.
	F7) Physical properties of eye movement-related eardrum oscillations (EMREOs) in the rhesus monkey Schlebusch, Stephanie N.; Kaylie, D.; King, C.; Shera, C.; Groh, J.	**L7) Multisensory memory benefits are object-specific** Duarte, Shea Elizabeth; Geng, Joy
	F9) Prior Exposure Enhances Cortical Entrainment to Unheard Speech during Silent Lip-reading Cao, Zhewei "Cody"; O'Sullivan, A.; Szymula, L.; Nidiffer, A.; Lalor, E.	**L9) Spatial action-effect binding depends on type of action-effect transformation** Liesner, Marvin; Kirsch, Wladimir; Pfister, Roland; Kunde, Wilfried
	F11) Short-term monocular deprivation boosts neural responsiveness to audio-visual events for the undeprived eye Federici, A.; Bernardi, G.; Senna, I.; Fantoni, M.; Ernst, M.; Ricciardi, E.; Bottari, D.	**L11) Sounds changing in pitch interact with proprioception when paired with body movement, affecting motor behaviour and bodily feelings** Ley-Flores, Judith; Bevilacqua, Frédéric; Bianchi-Berthouze, Nadia; Tajadura-Jimenez, Ana; Deroy, Ophelia
	F13) The contribution of visual dynamics and articulatory details to audiovisual speech perception in noise O'Sullivan, Aisling; Nidiffer, Aaron; Lalor, Edmund	**L13) Changing tactile amplitude and frequency perception via autosuggestion** Myga, Kasia Anna; Kühn, Esther; Azañón, Elena
	F15) Perceptual cognition during illusory self-motion: vection, cybersickness and top-down control Taylor, Paul; Obereisenbuchner, Florian; Dowsett, James	**L15) Delays in a virtual tracking task are detrimental to the feelings of ownership and agency** Stephens, Joey; Hibbard, Paul; van Dam, Loes
	[withdrawn] Time-to-collision estimates for accelerating vehicles show stronger audiovisual benefits for conventional compared to electric vehicles Oberfeld, Daniel; Wessels, Marlene; Dimmler, Vanessa	**L17) Flight of Mind – Multisensory & sensorimotor mechanisms underlying out-of-body experience Context** Song, Myeong Seop; Betka, Sophie; Lance, Florian; Herbelin, Bruno; Blanke, Olaf
	F19) Escape from Dizzyland: a web-based clinical rehabilitation program for people with Persistent Postural Perceptual Dizziness (PPPD) Goodwin, Nathan J.; Sumner, P.; Loizides, F.; Derry-Sumner, H.; Powell, G.	**L19) Listen to your fake hand: the effect of sound on the somatic rubber hand illusion** Tammurello, Carolina; Amadeo, Maria Bianca; Campus, Claudio; Setti, Walter; Tonelli, Alessia; Gori, Monica
	F21) Resampling through touch rather than vision when checking ambiguous stimuli: a new metacognitive bias Fairhurst, Merle Theresa; Travers, Eoin; Hayward, Vincent; Deroy, Ophelia	**L21) Patterns of spontaneous body exploration in infancy** Khoury, Jason Achille Michel; Popescu, Sergiu Tcaci; Marcel, Valentin; Gama, Filipe; Hoffmann, Matej
	F23) Visual and tactile signals to contact duration are not integrated, but signals to object properties are: implications for multisensory integration processes and artificial touch stimulation. Watt, Simon; Krishnan, Anantha; Doppertin, Lea; Seminara, Lucia	**L23) Visual experience shapes body schema** Shahzad, Iqra; Occelli, Valeria; Mouraux, André; Collignon, Olivier
	F25) Virtual Tool-use: Do Tool-use Effects Extend to Virtual Reality? Bell, Joshua D.; Macuga, Kristen L.	**L25) The impact of joint attention on the sound-induced visual illusions** Battich, Lucas; Garzorz, Isabelle; Wahn, Basil; Deroy, Ophelia
	F27) The Effect of Action on the Shape of Audio-Visual Temporal Binding Window Jagini, Kishore Kumar; Sunny, Meera Mary	**L27) Auditory Time to Contact Estimation and The Crucial Role of Temporal Cues** INCE, MELIS; BOLLINI, ALICE; CAMPUS, CLAUDIO; GORI, MONICA
	F29) Interacting with multi-material objects: Learning new density cues for grasping Mehraeen, Sina; Adams, Wendy J.; Ernst, Marc O.	**L29) Five Experiments, Including a Pre-Registered Replication, and Mini Meta-Analyses Find No Evidence That Sound-Shape Associations Modulate Audiovisual Temporal Order Judgements** Sourav, Suddha; Röder, Brigitte; Ambsdorf, Franka; Melissari, Andromachi; Arvaniti, Miketa; Vatakis, Argiro



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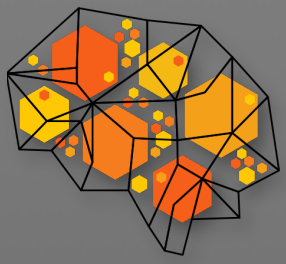
International Multisensory Research Forum

ULM 2022

Tuesday Afternoon Talks

	Room Danube	Room Lago
1:15pm - 2:45pm	**The Multisensory Brain** *Chair:* Olivier Collignon 1:15pm - 1:30pm Common neuronal assemblies integrate emotion expressions from the face and the voice Barbero, Francesca M.; Talwar, S.; Calce, R..; Rossion, B.; Collignon, O. 1:30pm - 1:45pm Selective responses to event timing are highly modality-specific. van Ackooij, Martijn; Paul, J.; van der Zwaag, W.; van der Stoep, N.; Harvey, B. 1:45pm - 2:00pm Hierarchical transformation of visual event timing representations in the human brain: response dynamics in early visual cortex and timing-tuned responses in association cortices Hendrikx, Evi; Paul, Jacob M.; van Ackooij, Martijn; Fracasso, Alessio; Dumoulin, Serge O.; van der Stoep, Nathan; Harvey, Ben M. 2:00pm - 2:15pm Local field potentials and single-units reflect multisensory integration in the medial pulvinar CAPPE, Céline; VITTEK, Anne-Laure; JUAN, Cécile; GAILLARD, Corentin; MERCIER, Manuel; NOWAK, Lionel G.; BEN HAMED, Suliann; GIRARD, Pascal 2:15pm - 2:30pm MVPA classification of natural sounds in early visual cortex Pollicina, Giusi; Dalton, Polly; Vetter, Petra 2:30pm - 2:45pm Structural and functional network-level reorganization in the coding of auditory motion directions and sound source locations in the absence of vision Battal, Ceren; Gurtubay-Antolin, A.; Rezk, M.; Mattioni, S.; Bottini, R.; Bertonati, G.; Occelli, V.; Maffei, C.; Jovicich, J.; Collignon, O.	Posters on Display
2:45pm - 3:15pm	Break	
3:15pm - 4:45pm	**Time, Space and Motion** *Chair:* Marko Nardini 3:15pm - 3:30pm Movement-induced bias in auditory spatial perception Locke, S.; Martolini, C.; Lunghi, C.; Lancelin, D.; Cappagli, G.; Gori, M.; Mamassian, P. 3:30pm - 3:45pm Parsing response times in multisensory decisions: the effect of signal strength and effector organ Otto, Thomas U.; Innes, Bobby R. 3:45pm - 4:00pm Auditory and Tactile Stimulation Selectively Increases the Perceived Speed of Visual Objects Meyerhoff, Hauke S.; Gehrer, Nina A.; Merz, Simon; Frings, Christian 4:00pm - 4:15pm A direct comparison of cue combination with familiar and newly-learned cues Scheller, Meike; Aston, Stacey; Slater, Heather; Nardini, Marko 4:15pm - 4:30pm Modeling the effects of attention on causal inference in multisensory perception Badde, Stephanie; Landy, Michael S 4:30pm - 4:45pm Modeling audiovisual temporal processing of ecological stimuli Parise, Cesare Valerio; Kurt, Aykut; Ernst, Marc	Posters on Display
4:45pm - 5:45pm		Poster Session 3
5:45pm - 7:00pm	**Keynote 2: Benedikt Grothe** The spatial representations of sounds A journey through time and along the auditory pathway	



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Tuesday Afternoon Posters

4:45pm - 5:45pm

Foyer

F2) Combined visual-auditory fear-related stimulation delayes the disengagement of spatial attention from an invalidly cued position: an ERP study
Zimmer, Ulrike; Wendt, Mike; Pacharra, Marlene

F4) Effects of musical expertise and response mapping on pitch-space crossmodal interactions
Wilbiks, Jonathan M.P.; Dincorn, Kailey

F6) Comparing eye movement-related eardrum oscillations (EMREOs) in subjects with normal hearing and auditory system dysfunction
King, Cynthia; Schlebusch, Stephanie; Kaylie, David; Shera, Christopher; Groh, Jennifer

F8) Effect of sensory reliability and saccadic eye-movements on multisensory integration in the spatial ventriloquism paradigm
BELLE, Aurélien; QUINTON, Jean-charles; LEFORT, Mathieu; CHAUVIN, Alan; GUYADER, Nathalie; AVILLAC, Marie

F10) Eye movement-related eardrum oscillations do not require current visual input
Abbasi, Hossein; King, Cynthia D.; Schlebusch, Stephanie; Röder, Brigitte; Groh, Jennifer M.; Bruns, Patrick

F12) How we adjust our movements in response to error feedback when intercepting moving targets
Bertonati, Giorgia; Gori, Monica; Brenner, Eli

F14) Memory task influence on postural stability and self-motion perception in virtual environment
Tixier, Maëlle; Cian, C.; Barraud, P.-A.; Laboissière, R.; Rousset, S.

F16) Motor Adaptation Distorts Visual Space
Petrizzo, Irene; Anobile, Giovanni; Arrighi, Roberto

F18) The Effects of Stimulus Salience dominate audio-visual Spatial Integration both in children and adults
Storm, Sina; Bruns, Patrick; Röder, Brigitte

F20) The sense of agency and the visuo-vestibular integration in self-motion perception
Rineau, Anne-Laure; Sarrazin, Jean-Christophe; Bringoux, Lionel; Berberian, Bruno

F22) Cognitive factors may affect the updating of an object's position during linear lateral translation.
Kim, John Jong-Jin; Harris, Laurence Roy

F24) Functional connectivity of visual and vestibular cortical regions
Becker, Markus; Frank, Sebastian M.; Beer, Anton L.; Greenlee, Mark W.

F26) Gravity vs Anti-gravity: can the Self-Motion-Induced Bias in Time-to-Contact Estimation be reversed?
Joerges, Bjoern; Harris, Laurence Roy

F28) Does Weber's law hold for self-movement signals that encode self-controlled head rotation?
Haynes, Joshua D.; Gallagher, Maria; Culling, John F.; Freeman, Tom C.A.

F30) Effects of a non-informative auditory feedback over touch in the blindness
Casado Palacios, Maria; Tonelli, Alessia; Campus, Claudio; Gori, Monica

F32) Naturalistic spatial precision correlates with the left-right discrimination threshold if head and trunk are not aligned
Esposito, Davide; Bollini, Alice; Gori, Monica

Room Lago

[withdrawn] Performing a task jointly reduces interference in a visual and an audiovisual Stroop task
Gearhart-Edwards, Anika; Wahn, Basil; Sinnett, Scott

L4) Spontaneous head-movements improve sound localization in aging adults with hearing loss
Gessa, Elena; Valzolgher, Chiara; Giovanelli, Elena; Spinella, Domenico; Verdelet, Grégoire; Farnè, Alessandro; Frau, Giuseppe Nicolò; Pavani, Francesco

L6) Sequential model of audiovisual integration of consonant clusters
Wlaszczyk, Agata; Gil-Carvajal, Juan Camilo; Andersen, Tobias Søren

L8) A machine learning approach to the crossmodal sound-symbolic word-shape correspondence
Kumar, G. Vinodh; Hoffmann, Ana Maria; Matthews, Kaitlyn L.; Lacey, Simon; Nygaard, Lynne C; Sathian, K.

L10) Dissociating the involvement of posterior superior temporal region in audio-visual processing through transcranial magnetic stimulation
Ahn, EunSeon; Brang, David

L12) How early visual deprivation affects the development of the visual cortices of blind humans
Czarnecka, Maria; Hryniewiecka, Katarzyna; Krześniak, Alicja; Dziegiel-Fivet, Gabriela; Plewko, Joanna; Vadlamudi, Jyothirmayi; Jednoróg, Katarzyna; Collignon, Olivier; Szwed, Marcin

L14) Selective Adaptation Is Sensitive To The McGurk Effect
Dorsi, Josh; Rosenblum, Lawrence D.; Sathian, K.; Zadoorian, Serena; Lacey, Simon

L16) The McGurk effect: A linguistic view of a multisensory speech illusion.
Liapi, Lydia Kalliopi; Vatakis, Argiro

L18) Unmasking the difficulties of listening to talkers with masks: lessons from COVID19 pandemic
Giovanelli, Elena; Valzolgher, Chiara; Gessa, Elena; Todeschini, Michela; Pavani, Francesco

In Talk Session: Wed. 10:15am) The role of ageing on self-reported ability across multiple senses: a longitudinal analysis.
O'Dowd, Alan M; Hirst, Rebecca J; Setti, Annalisa; Kenny, Rose Anne; Newell, Fiona N

[withdrawn] Increase of the audio-visual spatial integration window with age but not hearing loss
Huisman, Thirsa; MacDonald, Ewen N; Piechowiak, Tobias; Dau, Torsten

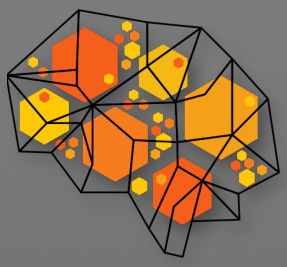
L24) Older adults with a history of falling exhibit altered cortical oscillatory mechanisms during continuous postural maintenance
Jiang, Fang; Scurry, Alexandra; Szekely, Brian; Murray, Nicholas

[withdrawn] The feeling of "kiki": select tactile exposure or visual imagery can enhance abstract audio-tactile crossmodal correspondences, the bouba-kiki effect, early in development
Ciaramitaro, Vivian; Kelly, Julia; Nguyen, Cuong

L28) Multi-modal object fusion in superior colliculus - a complete neuromorphic model
Schmid, Daniel; Oess, Timo; Neumann, Heiko

L30) Visuo-haptically guided grasping in cataract-treated children
Piller, Sophia; Senna, Irene; Wiebusch, Dennis; Volcic, Robert; Ernst, Marc O.

L32) Modulation of phonetic perception by invisible lip movements
Teramoto, Wataru; Ernst, Marc O.



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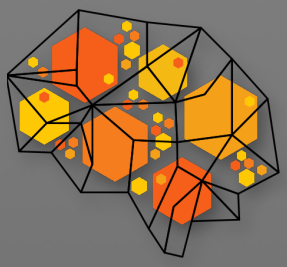
Wednesday Morning Talks

	Room Danube	Room Lago
8:30am - 9:15am	**Multisensory Concepts** *Chair*: Ophelia DEROY 08:30am - 08:45am Three metacognitive challenges to multisensory research DEROY, Ophelia 08:45am - 09:00am Seeing Music: leveraging citizen science and gamification to study cross-sensory associations Saitis, Charalampos; Cuskley, Christine; Löbbers, Sebastian 09:00am - 09:15am Body models in humans, animals, and robots: mechanisms and plasticity Hoffmann, Matej	Posters on Display
9:15am - 9:45am	**Spotlight Talk: Daphne Maurer** *Chair*: David Shore Pretty Ugly: Why we like some songs, faces, foods, plays, pictures, poems, etc., and dislike others	
9:45am - 10:15am	Break	
10:15am - 11:15am	**Chemical & Pain** *Chair*: Joost X Maier 10:15am - 10:30am The role of ageing on self-reported ability across multiple senses: a longitudinal analysis. O'Dowd, Alan; Hirst, Rebecca; Setti, Annalisa; Kenny, Rose Anne; Newell, Fiona 10:30am - 10:45am Multisensory interactions underlying flavor preference decisions: the role of experience Maier, Joost X; Garrison, Megan N 10:45am - 11:00am [video] Odour with Trigeminal Properties Ventriloquized Sound Liang, Kun; Chen, Lihan 11:00am - 11:15am Olfactory crossmodal correspondences are partly explained by the physicochemical features of odours Ward, Ryan Joseph; Wuerger, Sophie; Marshall, Alan	Posters on Display
11:15am - 12:15pm		Poster Session 4



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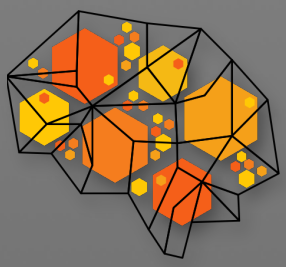
Wednesday Morning Posters

	Foyer	Room Lago
11:15am - 12:15pm	**F1) Cross-sensory inhibition or unisensory facilitation: neural architecture of multisensory processing** Cuppini, Cristiano; Ursino, M.; Magosso, E.; Crosse, M.; Foxe, J.; Molholm, S. **F3) Crossmodal central tendency effect of duration discrimination is dependent on stimulus order** Gao, Yi; Miller, Kamilla; Rudd, Michael; Webster, Michael; Jiang, Fang **[withdrawn] Mindfulness meditation biases visual temporal order discrimination but not in temporal ventriloquism** Tian, Yue; Chen, Lihan **F7) Unpredictability of correlated sensory signals does not enhance multisensory integration** Fuchs, Xaver; Wittbrock, Carolin; Heed, Tobias **F9) Characterising the neural correlates of cross-modal associations formed from unisensory stimulus presentations: a neurally-informed modelling approach** Bolam, Joshua William; Boyle, Stephanie Claire; Ince, Robin A.A.; Delis, Ioannis **F11) Characterizing auditory and visual motion processing and integration in hMT+/V5 and Planum Temporale with ultra-high-field fMRI (7T).** Barilari, Marco; Gau, Remi; Collignon, Olivier **F13) EEG evoked activity suggests amodal evidence integration in multisensory decision-making** Schaffhauser, Thomas; De Cheveigné, Alain; Boubenec, Yves; Mamassian, Pascal **F15) Modulation of perception by visual, auditory and audiovisual reward predicting cues** Antono, Jessica Emily; Pooresmaeili, Arezoo **F17) Representation of emotion expressions along the face and voice networks** Falagiarda, Federica; Gau, Rémi; Battal, Ceren; Rezk, Mohamed; Van Audenhaege, Alice; Collignon, Olivier **F19) Neural Mechanisms Underlying the Reversal of Hemianopia with Multisensory Training** Stein, Barry E.; Rowland, B.; Monti, M.; Magosso, E.; Cuppini, C. **F21) Audio-visual spatial aftereffects are based on multisensory perception and approximately optimal recalibration** Kramer, Alexander; Bruns, Patrick; Röder, Brigitte **F23) Typical resting state activity of the brain requires visual input during an early sensitive period** Rączy, Katarzyna; Hölig, C.; Guerreiro, M.; Lingareddy, S.; Kekunnaya, R.; Röder, B. **F25) Strategic re-aiming decreases perceptual precision during motor adaptation** Will, Matthias; Stenner, Max-Philipp **F27) The effect of Audio-visual-haptic Training on Learning in a Virtual and Physical Environment** Batterley, Michael David Sheldon **F29) The dynamic interplay of multisensory and motion influences on visual completion** Kurian*, Grace S.; Retsa*, Chrysa; Murray, Micah M. **F31) Multisensory Integration in Enhancing Affective Experience** Kim, SuKyoung	**L1) Can impersonal touch replace interpersonal touch? An investigation using the rubber hand illusion** Bae, Jaehyoung; Wallraven, Christian **L3) Contributions of Body Ownership to Memory Accuracy and Phenomenology** Iriye, Heather Miyoko; Ehrsson, H. Henrik **L5) Referral of sensation via mirror reflection – effect, best techniques and nature of responders – a mixed-methods within-person cross-over study** Hagenberg, Annegret; Maltby, John; Gillies, Clare; Jussab, Shifa; Lambert, Dave; Robinson, Thompson **L7) Dissociations and interactions between illusory part- and full-body ownership** O'Kane, Sophie Helena; Ehrsson, H. Henrik **L9) Enhanced cardiac interoceptive accuracy is related to cortical thickness of the occipital cortex in congenitally blind individuals** Stroh, Anna-Lena; Radziun, Dominika; Korczyk, Maksymilian; Ehrsson, Henrik; Szwed, Marcin **L11) Rethinking Reality through Unreality** Cho, Youngil **L13) Sound Congruence and the Rubber Hand Illusion** Coppi, Sara; Ehrsson, H.Henrik **L15) Spatially mediated interactions between singletons in tactile search** Gherri, Elena; Ambron, Elisabetta **L17) The representation of peripersonal space around upper and lower limbs** Xi, Aolong; Sedda, Anna; Gherri, Elena **[withdrawn] The audiovisual advantage in pedestrians' road crossing decisions is significantly reduced for accelerating electric compared to conventional vehicles** Wessels, Marlene; Oberfeld-Twistel, Daniel **L21) The relationship between vestibular thresholds and balance tasks in a multisensory environment** Zanchi, Silvia; Cuturi, Luigi F.; Sandini, Giulio; Gori, Monica **L23) Vestibular cues to self-motion contribute to route memory and spatial navigation in a simulated driving task** Jabbari, Yasaman; Kenney, Darren M; Mohrenschildt, Martin Von; Shedden, Judith M **L25) Impact of imposed physical distancing on multisensory experiences** Kirsch, Louise; Spence, Charles; Auvray, Malika **L27) Cross condition differences in multi-sensory sensitivities: insights from a mixed-methods approach** Price, Alice; Ghaiwal, Abhay; Griffin, Charlotte; Sumner, Petroc; Powell, Georgina **[withdrawn] Deficient Multisensory Integration with concomitant structural connectivity in adult ADHD** Schulze, Marcel; Lux, Silke; Philipsen, Alexandra **L31) PsySuite: performing multimodal portable psychophysics within the Android environment** Domenici, Nicola; Inuggi, Alberto; Tonelli, Alessia; Gori, Monica



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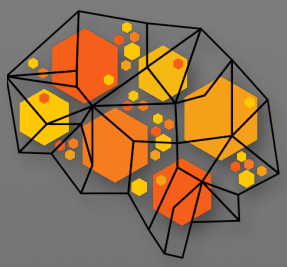
Wednesday Afternoon Talks

	Room Danube	Room Lago
1:15pm - 2:45pm	**Multisensory Development** *Chair:* Monica Gori 1:15pm - 1:30pm A brief period of postnatal visual deprivation selectively alters visual motion processing in early visual regions Rezk, Mohamed; Mattioni, S.; Gau, R.; Nam, J.; Liu, Z.; Gao, X.; Lewis, T.; Maurer, D.; Collignon, O. 1:30pm - 1:45pm Effects of early auditory deprivation on visuo-tactile temporal processing Jiang, Fang; Chifamba, Kudzai; Scurry, Alexandra N. 1:45pm - 2:00pm Interactions between auditory statistics processing and visual experience emerge only in late development Berto, Martina; Ricciardi, Emiliano; Pietrini, Pietro; Bottari, Davide 2:00pm - 2:15pm How vision shapes the development of allocentric spatial frame Bollini, Alice; Gori, Monica 2:15pm - 2:30pm The development of cortical activity during waking and sleep stages in children with and without visual impairment Vitali, Helene; Campus, C.; Signorini, S.; De Giorgis, V.; Gori, M. 2:30pm - 2:45pm Visuo-haptic processing of unfamiliar shapes: comparing children and adults Alahmad, Furat; Rau, Anne; Wallraven, Christian	Posters on Display
2:45pm - 3:15pm	Break	
3:15pm - 4:45pm	**Vestibular / Self-Motion** *Chair:* Laurence Harris 3:15pm - 3:30pm Multisensory Integration of Audio-Visual Motion Cues during Active Self-Movement Gallagher, Maria; Culling, John F.; Freeman, Tom C. A. 3:30pm - 3:45pm Vestibular and visual brain areas in the medial cortex of the human brain Beer, Anton L.; Markus, Becker; Frank, Sebastian M.; Greenlee, Mark W. 3:45pm - 4:00pm Pluri-sensory puzzles of Persistent Postural Perceptual Dizziness (PPPD) Sumner, Petroc; Powell, G.; Price, A.; Gamble, R.; Goodwin, N.; Loizides, F.; Derry-Sumner, H.; Rajenderkumar, D.; Rushton, S. 4:00pm - 4:15pm Estimating travel distance differs depending on the direction, but not speed of self-motion Bansal, Ambika Tara; McManus, Meaghan; Harris, Laurence 4:15pm - 4:30pm Greater accuracy and precision in visual-vestibular conflict detection is associated with lower VR sickness Halow, Savannah Jo; Hamilton, Allie; Folmer, Eelke; MacNeilage, Paul 4:30pm - 4:45pm Characterization of head orientation and heading during everyday activity: implications for modeling. Sinnott, Christian B.; Hausamann, Peter A.; MacNeilage, Paul R.	Posters on Display
4:45pm - 5:45pm		Poster Session 5
5:45pm - 7:00pm	**Keynote 3: Albrecht Schmidt** Interacting with Intelligent Systems: Human-AI Collaboration to Amplify Human Abilities	



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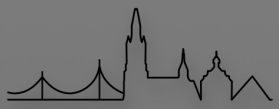
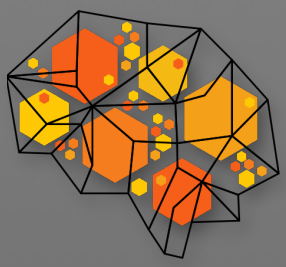


ULM 2022

Wednesday Afternoon Posters

	Foyer	Room Lago
4:45pm - 5:45pm	**F2) Immersion in multisensory virtual environments changes willingness to pay** Tang, Jiawen; Ward, Ryan; Meyer, Georg **F4) Quantifying Self-Motion Sensations Induced by Artificial Vestibular Stimulation** Ferrè, Elisa Raffaella; Gallagher, Maria; Romano, Fausto; Bockisch, Chris; Bertolini, Giovanni **F6) Unimodal Weights in Bimodal Perception: Influence of intermodal differences in stimulus reliability and task induced saccades on crossmodal bias** Rieger, Alisa; Quinton, Jean-Charles; Lefort, Mathieu; Guyader, Nathalie; Chauvin, Alan; Avillac, Marie **F8) A methodology for creating consonant symphonies by integrating all senses** Pantidos, Constantinos George **F10) Assessing Cortical Hyperresponsivity and Habituation in Migraine, according to Age and Disease Severity, using Visual Evoked Potentials during Pattern-Reversal Stimulation** Marti-Marca, A.; Vilà-Balló, A.; Cerdà-Company, X.; Ikumi, N.; Torralba, M.; Torres-Ferrus, M.; Caronna, E.; Gallardo, V.; de la Torre, A.; Alpuente, A.; Soto-Faraco, S.; Pozo-Rosich, P. **F12) Bilateral cochlear implants enable audio-visual attention orienting** Valzolgher, Chiara; Farnè, Alessandro; Truy, Eric; Pavani, Francesco **[withdrawn] Bouncing or streaming: Crossmodal interaction of audiovisual events by eye tracking** Jin, Yingxiao; Chen, Lihan **F16) How does multisensory training facilitate voice learning?** Zadoorian, Serena; Rosenblum, Lawrence D. **F18) Influence of gravitoinertial cues on the perception of looming auditory stimuli** TAFFOU, Marine; VIAUD-DELMON, Isabelle; HARTNAGEL, David **F20) Low-level and automatic facilitation of perception of degraded speech by vision** Nishikawa, Kotomi; Ujiie, Yuta; Takahashi, Kohske **[withdrawn] Selective enhancement of parvocellular visual processing by looming sound** Yamasaki, Daiki; Nagai, Masayoshi **F24) Semantic incongruency in audiovisual object recognition task disrupts patients with schizophrenia less than healthy controls** Ghaneirad, Erfan; Engels, Anna; Bleich, Stefan; Szycik, Gregor **[withdrawn] Sequential modulation of the Cross-modal Congruency effect: the role of target and distractor sensory modality** Mas Casadesus, Anna; Gherri, Elena **F28) The faster it looms, the faster I detect it: Multisensory integration of looming signals within the autistic traits spectrum.** POULAIN, Rachel; BATTY, Magali; CAPPE, Céline **F30) Tonal music fits with saturated lighting: The perceived fit of music and colored ambient light depends on crossmodally evoked emotions** Hauck, Pia; von Castell, Christoph; Hecht, Heiko **F32) The soundtrack of my body: Implicit body weight distortions in auditory-driven body illusion in subclinical and clinical eating disorders** Tajadura-Jiménez, A.; Crucianelli, L.; Zheng, R.; Cheng, C.; Ley-Flores, J.; Bordá-Más, M.; Bianchi-Berthouze, N.; Fotopoulou, A.	**L2) Cue Combination in Weight Perception** Kristiansen, Olaf; Scheller, Meike; Aston, Stacey J.; Kentridge, Robert W.; Nardini, Marko **L4) Heavy = valuable? The impact of packaging weight on product evaluations and behavioral intentions** Kampfer, Kristina **L6) How visuomotor predictability affects tactile suppression: Slicing objects with a sword in virtual reality** McManus, Meaghan; Schütz, Immo; Voudouris, Dimitris; Fiehler, Katja **L8) Viewed touch influences tactile detection by altering decision criterion** Nair, Anupama; Medina, Jared **L10) Cognitive Impacts on the Crossed-Hands Deficit: Examining the Influence of Visual Imagery and Attention** Lorentz, Lisa; Unwalla, Kaian; Shore, David I. **L12) Perceptual size-weight illusion in haptic augmented virtual reality** Günter, Clara; Franklin, David; Leib, Raz **L14) The Effects of Vision on Static-Touch Coarse Roughness Discrimination** Li, Min; Roberts, Roberta; Di Luca, Massimiliano; Allen, Harriet; Wing, Alan **L16) The size-weight illusion still occurs at minimal size and density differences** Pisu, Veronica; Graf, Erich W.; Adams, Wendy J. **L18) Visual-tactile integration for Roughness Estimation in Augmented Reality** Filipovica, Maija; Singh, Nishant; Roberts, Roberta; Li, Susan Min; Abdlkarim, Diar; Di Luca, Massimiliano; Wing, Alan Miles **L20) New measures of multisensory integration in reaction times based on relative entropy** Colonius, Hans; Diederich, Adele **L22) Signal Detection Theory and multisensory coupling** van Dam, Loes C.J.; May, Keith A. **[withdrawn] Visually guided redirection of reaching actions reveals an enhanced efficiency of online motor corrections towards the body midline** Maselli, A.; Ofek, Eyal; Cohn, Brian; Ken Hinckley, Ken; Gonzalez Franco, Mar **L26) CatchU: A Novel Visual-Somatosensory Integration Tool for Assessing Fall Risk** Mahoney, Jeannette R.; George, Claudene; Verghese, Joe **L28) Intertrial tendon vibration but not agonist muscle fatigue affects visual-proprioceptive sensory weighting during goal-directed movement** Manzone, Damian Matricciano; Rudecki, Julia; Tremblay, Luc **L30) Motor adaptation affects sensory processing of numerosity directly: evidence from reaction times and confidence** Maldonado Moscoso, Paula Andrea; Cicchini, Guido Marco; Arrighi, Roberto; Burr, David Charles **L32) The Effects of Multiple Physical Factors on Creative Thinking, A Field Study** Augustin, Sally Jean; Milota, Cynthia **L34) Metacognition Distinguishes Congruent and Illusory Multisensory Perceptions** Odegaard, B.; Kimmet, F.; Mims, C.; Preston, A.; Westmoreland, K. Lolo K.; Rosario, N.; Pedersen, S.; Cardenas, V.; Rubiera, C.; Johnson, G.; Sans, A.; Maynes, R.



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Thursday Morning Talks

	Room Danube	Room Lago
8:30am - 9:45am	**Body / Action** *Chair:* **Wahn, Basil** **8:30am - 8:45am** Audiovisual integration during joint action: How does performing a task jointly affect multisensory perception? **Wahn, Basil; Dosso, Jill; Keshava, Ashima; Gearhart, Anika; Rohe, Tim; König, Peter; Sinnett, Scott; Kingstone, Alan** **8:45am - 9:00am** Contribution assignment in a joint virtual task **Ramundo, Teresa; Balestrucci, Priscilla; Moscatelli, Alessandro; Ernst, Marc O.** **9:00am - 9:15am** Full body motor representation in human amygdala **Aggius Vella, Elena; Amedi, Amir** **9:15am - 9:30am** Extending the Bayesian Causal Inference of Body Ownership Modell Across Time **Schubert, Moritz; Endres, Dominik** **9:30am - 9:45am** Holding an object with a tool improves visually guided grasping **Camponogara, Ivan; Farnè, Alessandro; Volcic, Robert**	**Tactile** *Chair*: **Elena Azañón** **8:30am - 8:45am** Tactile aftereffects as a psychophysical window onto receptive field organization **Azañón, Elena; Frisco, Francesca; Hoffmann, Benjamin; Stenner, Max-Philipp; Longo, Matthew** **8:45am - 9:00am** [video] The primitive priming sense: an updated functional account of how affective touch facilitates cross-modal processing **Fairhurst, Merle Theresa; Croy, Ilona; McGlone, Francis** **9:00am - 9:15am** Overlapping neural representations between touch to self and others in people with high tactile empathy **Smit, Sophie; Moerel, Denise; Zopf, Regine; Rich, Anina** **9:15am - 9:30am** Coordinate Transforms Mediating Tactile Motion Representations with the Hand **Ahuja, Himanshu; Shivkumar, Sabyasachi; Fesitritzer, Catalina; Haefner, Ralf M.; DeAngelis, Gregory C.; Gomez-Ramirez, Manuel** **9:30am - 9:45am** Neural correlates of tactile representations in somatotopic and external reference frames **Raigosa-Posada, Luisa M.; Liu, Yuqi; Medina, Jared**
9:45am - 10:15am	**Break**	
10:15am - 11:15am	**Temporal Dynamics in Audiovisual Integration** *Chair(s):* **Weiland, Ricarda Florine, Jertberg, Robert** Audiovisual Synchrony Perception in Adults with and without Autism **Weiland, Ricarda Florine, Polderman, Tinca JC, Smit, Dirk JA, Begeer, Sander, Van der Burg, Erik;** Multisensory temporal function in autism **Wallace, Mark T, Noel, Jean-Paul, Stevenson, Ryan Andrew, Woynaroski, Tiffany G;** Temporal Dynamics of the McGurk Effect in Autism **Jertberg, Robert, Begeer, Sander, Geurts, Hilde, Chakrabarti, Bhismadev, Van der Burg, Erik;** From Cacophony to Synchrony: Multisensory Integration and Recalibration with Competing Stimuli **Van der Burg, Erik, Jertberg, Robert, Kruijne, Wouter;**	**Advances in Neural Modelling of Multisensory Integration** *Chair(s):* **Shaikh, Danish** Drift-diffusion models of tactile reaction times with looming auditory stimuli **Sancristobal, Belen, Ferri, Francesca, Perrucci, Mauro Gianni, Romani, Gian Luca, Northoff, Georg, Longtin, Andre;** Multi-sensory integration in the mouse cortical connectome using a network diffusion model **Shadi, Kamal, Dyer, Eva, Dovrolis, Constantine;** [video] Efficient coding as the provenance of matched and opposite neuronal feature preferences for multisensory and multi-modal inputs **Li, Zhaoping;** Learning priors: modelling developmental multisensory cue combination **Shaikh, Danish;**
11:15am - 11:30am	**Break**	
11:30am - 1:00pm	**Deafness and blindness as insights into cognition** *Chair(s):* **Cardin, Velia** Multisensory processing of prosodic information in cochlear implanted deaf patients. **Barone, Pascal, Lasfargue, Anne, Deguine, Olivier, Marx, Mathieu;** How technology, life experiences and mental imagination shapes brain specialization and can be used for visual and auditory impairments **Amedi, Amir;** What early auditory deprivation tells us about multisensory recognition of person identity in the human brain **Benetti, Stefania, Rabini, Giuseppe, Novello, Lisa, VanAckeren, Markus, Maffei, Chiara, Rezk, Mohamed, Zonca, Joshua, Rossion, Bruno, Pavani, Francesco, Jovicich, Jorge, Collignon, Olivier;** Data-driven classification of spectral profiles reveals brain region-specific plasticity **Rimmele, Johanna M., Lubinus, Christina, Orpella, Joan, Keitel, Anne, Gudi-Mindermann, Helene, Engel, Andreas K., Röder, Brigitte;** How visual is the number sense? Insights from blindness. **Crollen, Virginie;** Crossmodal plasticity and executive functions in deaf individuals **Cardin, Velia, Vinogradova, Valeria, Woll, Bencie, Eimer, Martin, Manini, Barbara;**	**The non-veridical perception of touch: psychological and neural mechanisms and current theoretical approaches** *Chair(s):* **Kilteni, Konstantina, Heed, Tobias** (Mis)perceiving tactile location: Touch is coded anatomically, not externally, for tactile-spatial forced-choice tasks **Heed, Tobias;** (Mis)perceiving tactile location using the mirror box illusion: Examining the relationship between perceived touch and embodiment **Medina, Jared;** (Mis)perceiving touch intensity: action prediction attenuates self-generated touches compared to externally generated ones **Kilteni, Konstantina;** Perceiving touch without tactile stimulation: the curious case of the 'Autonomous Sensory Meridian Response' **Poerio, Giulia, Gillmeister, Helge;**
1:00pm - 2:00pm	**Closing & Business Meeting**	

Monday Afternoon Symposium Talks

Monday Symposium

12:15pm - 1:30pm

Room Danube

Multisensory development: localization, learning, and sensory loss

Dewe, Hayley; Cowie, Dorothy

Our perception and ability to effectively interact within our environments is fuelled by rich and coherent multisensory representation. Development and sensory loss can fundamentally alter the ways in which the senses are integrated. Further, this multisensory information is used to scaffold embodiment and learning. In this symposium we examine both how fundamental processes of multisensory perception change during development, and the effects that these can have on wider cognitive and perceptual function. We focus first on these issues during infancy, before presenting studies on childhood and finally adulthood. The first talk (Monica Gori) examines how orienting responses to auditory and tactile targets differ in blind and sighted infants. The data demonstrate how multisensory processes can change as a result of very early developmental experience including sensory loss. The second talk (Walter Setti) studies blind and sighted children to show that visual experience impacts on auditory spatial representations and their structure in memory. Therefore, multisensory perception can support memory processes in childhood. The third talk (Dorothy Cowie) examines how visuomotor and visuotactile signals underpin children's embodiment of hands, a unique and key feature of the child's perceptual and motor environment. Complementing this, the fourth talk (Hayley Dewe) studies the role of visuomotor signals in the child's perception of their moving whole body, which is thought to better reflect the multisensory processing underlying the sense of self. The final talk (Marko Nardini) examines how key multisensory computations can change later in life, by studying how adults can learn new sensory skills. These include novel auditory or vibrotactile cues, which can be used to judge distance, weight, or intercept a moving object. Collectively, these findings will present new insights into the function, development and constraints of multisensory processing which underlie complex and coherent representation in infancy through to adulthood.

Orienting responses to tactile and auditory stimuli on the hands in sighted and blind infants.

Bremner, Andrew J.[1], Campus, Claudio[2], Tonelli, Alessia[2], Signorini, Sabrina[3], Gori, Monica[2];
[1]University of Birmingham, United Kingdom, [2]Istituto Italiano di Technologia, Italy, [3]IRCCS Mondino Foundation, Italy

Visual deprivation in early postnatal development impairs the acquisition of spatial representations in non-visual modalities including touch and hearing (Azañón et al., 2018; Gori et al., 2014; Roder et al., 2004). This indicates that visual experience plays an important role in the ontogeny of spatial representations, a role seemingly confirmed by observations of delayed development of a wide range of perceptual and motor skills in blind infants and children (Cappagli et al., 2017; Cappagli & Gori, 2016; Elisa et al., 2002; Gori et al., 2010; Hallemans et al., 2011; Levtzion-Korach et al., 2000; Vercillo et al., 2016). Yet very little research has examined the development of spatial perception and multisensory processing in blind infants. We report a study in which we measured the accuracy of blind and sighted infants' manual orienting responses to auditory and tactile targets presented on the hands. Adapting a procedure used for measuring tactile localisation in sighted infants (Bremner et al., 2008), we presented stimuli on the hands following which we recorded the accuracy of the first movement of the hands. When tactile and auditory stimuli were presented at incongruent locations across the hands, the blind children orienting to the touches, and the sighted children orienting to the sounds. But both sighted and blind children demonstrated improved localisation when auditory stimuli were presented alongside tactile stimuli. We argue that these findings reflect an impairment of auditory localisation in blind infants, but that spatial localisation can be enhanced by providing spatially coherent stimulation across audition and touch.

Memory and sounds: the effect of early visual deprivation on mnestic skills in blind kids.

Setti, Walter, Cuturi, Luigi F., Gori, Monica;
Istituto Italiano di Technologia, Italy

The working memory (WM) system is, by definition, multisensory because the generation of complex images built from memorized items depends upon the integration of multiple independent representations regardless of their sensory nature. Developmental studies demonstrated that the neural processes underlying WM functionalities develop during the first years of life and strongly rely upon multisensory correspondences. Although visuospatial and verbal memory in children has been widely studied, audio spatial memory abilities have not been fully investigated in the case of typical or atypical development. Congenital blindness affects the processing of haptic spatial layouts, but little is known about the effect of early visual deprivation when it comes to audio spatial skills, especially in the first period of life. We tested congenitally blind and sighted children with educational games adapted to audition. The children explored and memorized complex auditory structures created with the combination of semantic sounds that had to be coupled and recalled based on their acoustic features or associative relations. To provide spatiality of the auditory stimuli, we developed novel technological solutions thought for congenitally blind individuals of all ages that combine the use of spatialized sounds and haptic exploration. Results highlight the chief role of visual experience in the processing of audio spatial representations and the consequent recalling of the items belonging to audio spatial structures. These studies, therefore, provide valuable insights into the role played by visual experience in shaping the refinement of auditory maps and shed light on the supramodal nature of high-order cognitive mechanisms across development.

Visuotactile and visuomotor synchronicity in the developing sense of self.

Cowie, Dorothy[1], Dewe, Hayley L.[1], Bird, Laura-Ashleigh[1], Brenton, Harry[2], Gillies, Marco[3];
[1]Durham University, United Kingdom, [2]Bespoke VR, London, United Kingdom, [3]Goldsmiths, University of London, United Kingdom

A stable sense of self is established through multisensory integration of signals (e.g., visual, tactile, motor), as well as prior knowledge about one's body. While this plays a crucial role in daily interactions and the growing self-concept, relatively little is known about these body representations in school-aged children. In two experiments, we examined the effects of movement, touch, and form on children's embodiment of virtual hands. A total of 197 children (4-14 years) played a virtual reality bubble-popping game where a virtual hand moved synchronously or asynchronously with their own. In Experiment 1 only, participants either received congruent touch, delayed touch, or no touch upon hitting each bubble. In Experiment 2 only, participants used either a virtual human hand or non-human block. Movement synchrony influenced embodiment ratings in both experiments. In Experiment 1, touch had no influence on embodiment. In Experiment 2, participants embodied both virtual forms, provided visuomotor signals were synchronous. However, only the virtual hand during synchronous movement was described as feeling like the participant's own body, rather than like a tool (e.g., controller). Findings highlight the dominance of visuomotor synchrony for children's own-body representation over visuotactile cues, and its interaction with prior expectations regarding body form.

The bodily self: visuomotor synchrony of virtual whole bodies in children and adults.

Dewe, Hayley L, Sill, Oscar, Kentridge, Robert, Cowie, Dorothy;
Durham University, United Kingdom

Understanding how children use visuomotor multisensory information to perceive ownership and control over their own bodies is a key topic in developmental psychology and bodily self-consciousness. In this experiment we induced an illusion of full-body transfer to a virtual avatar in a sample of 10 children (5-6 years) and 20 adults (18-26 years). The virtual body moved in synchrony or asynchrony with the participant's own. That is, the avatar was either matched in visuo-spatial location and controlled by the user, or movements were pre-recorded (unmatched visuo-spatial location with no user control). Embodiment was quantified via ratings of ownership (body belonging) and agency (body control), and objective psychophysiological measures in the form of skin conductance responses to a virtual body threat (looming snowballs). Findings revealed an effect of ownership for both children and adults when visuomotor feedback was synchronous, with children feeling this effect to a marginally stronger extent than adults. There was also an effect of agency during only synchronous visuomotor conditions, and this did not differ between children and adults. No differences in the body-threat skin conductance responses were observed across any experimental conditions. Overall, this demonstrates an overall dominance of visuomotor synchrony in driving body representation in both children and adults, and that children rely on visuomotor feedback for embodiment much earlier than previously suggested, despite not yet possessing an adult-like level of precise control over their movement.

Multisensory benefits with new sensory skills.

Nardini, Marko[1], Negen, James[2], Thaler, Lore[1];
[1]Durham University, United Kingdom, [2]Liverpool John Moores University, United Kingdom

New technology offers possibilities to augment human skills – to overcome sensory loss (e.g. devices providing 'visual' information via other modalities), and to enhance healthy perception. However, evidence from children suggests it takes many years to show efficient multisensory computations such as reliability-weighted averaging. In a wide-ranging new research programme, we are testing how key multisensory computations emerge during adult learning of new sensory skills. In our studies, sighted adults are provided with novel auditory or vibrotactile cues, alongside more typical visual cues, to judge distance (Expt 1, 2), intercept a moving object (Expt 3), or judge an object's weight (Expt 4, 5). Across these studies, we test model predictions for multisensory computations, e.g. weighted averaging, forced fusion, reaction times (the redundant signals effect). Initial results show that in sighted adults, newly-learned sensory skills exhibit some key multisensory benefits after only a few hours of experience. We find improved precision (via reliability-weighted averaging), faster reaction times, and higher success rates of ballistic interceptions. Abilities tested so far also appear resistant to a verbal dual task, one indicator that they do not rely on very different processes to typical perception. However, we do not yet see evidence for forced fusion, an effect analogous to the size-weight illusion, or reaction time gains beyond those predicted by race models. Next, we will examine effects of much longer training, and of sensory manipulations that may improve plasticity. We will also use neuroimaging to determine where in the brain multisensory computations are altered by training.

IMRF

International Multisensory Research Forum

ULM 2022

Monday Afternoon Symposium Talks

Monday Symposium

12:15pm - 1:30pm

Room Lago

Auditory influences on low-level vision

Störmer, Viola

Sounds can modulate activity in early visual cortex, enhancing perceptual processing and subsequent behavioral responses. However, broader functional characterizations of low-level auditory-visual interactions have remained more elusive and are worthy of critical discussion. For example, while research in animals has revealed multiple pathways that could enable sounds to influence early visual activity -- including indirect connections through multisensory association cortex, feedforward activity from subcortical structures, and monosynaptic projections from auditory to visual cortex -- it is unknown how each of these might contribute to auditory-visual effects observed in humans. This symposium focusses on recent advances in our understanding of low-level auditory-visual interactions in humans with an eye towards their functional characterization across multiple dimensions, including: What networks and mechanisms support auditory-driven activation of visual cortex? What is the role of attention? How fine-grained is the spatiotopic nature of sound inputs into visual cortex? How automatic are auditory-visual interactions? What is the relationship between "early" and "late" crossmodal responses in visual cortex? What information is relayed from auditory to visual areas? Presenters from differing vantage points will show findings that help reconcile potentially discordant evidence, provide integrative models accounting for low-level auditory visual interactions, and identify important open questions in the field.

Visual cortex responds to transient sound changes without encoding complex auditory dynamics

Ahn, EunSeon, Brang, David;
University of Michigan

Signals encoded in one sensory modality can enhance cortical sensitivity for co-occurring signals in another modality. Previous research has demonstrated that this facilitation occurs through crossmodal modulations of cortical oscillatory activity. However, the neural origin of these signals and auditory information conveyed by this mechanism remain poorly understood. Using human electrocorticography (ECoG), we examined the temporal dynamics of crossmodal modulations to identify the level of hierarchical coding at which auditory information is transmitted to visual cortex. Subcortical auditory neurons exhibit frequency following behaviors in response to amplitude-modulated sounds, with oscillatory activity entrained at the rhythmic rate of the auditory signal. This auditory response is paralleled in the visual system by the entrainment of visual neurons to the rhythmic rate of flashing strobe lights. In contrast, ~20% of neurons in auditory cortex do not entrain to amplitude modulations but respond only to the onsets and/or offsets of auditory stimuli. In visual cortex, amplitude-modulated sounds elicited transient onset and offset responses in multiple areas, but no entrainment to the sounds' modulations frequencies. These results suggest that auditory information conveyed to visual cortex does not include temporally fine-grained stimulus dynamics encoded by the auditory midbrain and thalamus but, rather, a temporally segmented representation of auditory events that emerges only in auditory cortex. Crossmodal responses were maximal in low-level visual cortex, potentially implicating a direct pathway for rapid interactions between low-to-mid-level auditory and visual cortices. This mechanism may facilitate perception by time-locking visual computations to environmental events marked by discontinuities in auditory input.

Sound-induced activation of the occipital cortex enhances visual perception

Störmer, Viola;
UC San Diego & Dartmouth College

Several studies have shown that hearing a salient sound can have significant influences on visual processing of a subsequent stimulus at the same location. These changes in perceptual processing are accompanied by neural changes within visual areas: EEG studies have revealed that a peripheral sound elicits a slow positive deflection over posterior scalp sites that is larger over the hemisphere contralateral to the sound. This Auditory-evoked Contralateral Occipital Positivity (ACOP) is accompanied by a contralateral decrease of the occipital alpha rhythm – a brain oscillation that has been closely linked to visual processing and visual-spatial attention. Recent studies raised a debate on how robustly these neural changes occur across different tasks and what the role of attention is in eliciting these responses. In this talk, I will address these questions by investigating how ACOP and alpha activity vary depending on attentional demands of the tasks, and I will compare the time course and magnitude of these two neural effects. I will show that both are consistently elicited by sounds across different task contexts, but that their time courses differ, suggesting at least in part distinct processes. Furthermore, by introducing a non-peripheral sound that alerts participants but does not provide spatial information, I will examine to what extent these sound-induced changes in visual cortex represent facilitatory or suppressive effects. Together, these results indicate that salient sounds can have multiple influences on visual-cortical activity to jointly improve visual perception.

Low-level supramodal activation of sensory cortices during complex spatial and temporal tasks

Amadeo, Maria Bianca, Campus, Claudio, Gori, Monica;
U-VIP Unit for Visually Impaired People, Fondazione Istituto Italiano di Tecnologia

Low-level areas once thought dedicated to processing information of a given sensory modality are now known to process inputs from multiple senses. The multisensory nature of the brain has been described as supramodal, meaning it reflects a cortical architecture for which task, rather than sensory system, is the primary design principle. All sensory modalities are constantly involved in the task of creating a spatial and temporal representation of the world. However, when representing space, people primarily relies on visual information, and when representing time, the most reliable information is audition. Recently, we showed complex spatial representation of sounds elicit an early ERP response in visual occipital areas. This activation mimics some characteristics of the C1 component usually elicited by visual stimuli. As the C1, it is 50-90 ms after the stimulus and it is contralateral with respect to the stimulus spatial position. Specularly, we showed complex temporal representation of flashes elicit an early activation of temporal regions, which seems to involve part of the auditory cortex. This ERP response shows some similarities with the N1 component usually evoked by auditory stimuli. Indeed, it consists of early (50-90ms) negativity in fronto-central areas, and positivity in temporal regions contralateral with respect to the stimulus spatial position. Thus, complex auditory spatial representation and visual temporal representation seem to require the early recruitment of low-level visual and auditory networks respectively. These findings suggest that the spatial and temporal domains could underlie and partially explain the task-specific supramodal organization of the visual and auditory cortices.

Time course and specificity of crossmodal prediction in visual cortex

Stange, Liesa, Ossandón, José, Röder, Brigitte;
Biological Psychology and Neuropsychology, University of Hamburg, Germany

Multisensory associative learning has been used to study crossmodal predictions in sensory cortex. However, the exact time course and precision of such predictions are yet unknown. In the present study, participants were exposed to frequent audio-visual combinations (two different tones and a Gabor patch in the bottom-left (A1V1) or in the top-right visual field (A2V2)). The EEG was recorded to these frequent crossmodal combinations as well as to rare crossmodal mismatching stimuli (A1V2, A2V1) and visual omissions (A1, A2). Frequent crossmodal combinations (A1V1 and A2V2) elicited an amplitude reversal between 50 and 100 ms, indicative of a C1 wave signaling early visual cortex activity. By contrast, such an effect was not observed for omissions (A1 vs A2). Lateralized positive and negative error signals with a posterior scalp topography were observed starting at 140 ms. These results suggest that that crossmodal predictions result in error signals, which code precise stimulus features such as the spatial location of the visual stimulus.

Multisensory plasticity supporting vision rehabilitation

Murray, Micah M.;
University of Lausanne

The 21st century has witnessed a paradigm shift in conceptions of the brain's functional organization. This talk first overviews evidence that instead of sensory systems operating in relative isolation, multisensory processes transpire at early and low-level stages; primary visual cortices are inherently multisensory. Two further lines of evidence show that multisensory processes also benefit vision rehabilitation. First, sounds enhance visual completion; a laboratory example of which is illusory contours (ICs) or borders perceived in the absence of contrast gradients. Hitherto, IC processes were considered exclusively visual in nature and unaffected by other sensory information. Not only is IC discrimination enhanced, but sounds also functionally couple brain responses within a network of primary visual, inferior parietal and lateral occipital cortices within the initial 100-150ms of stimulus processing. These findings impact visual rehabilitation strategies, because IC processes are impaired in sight-restored individuals despite intact low-level vision. Second, we detail the spatio-temporal brain dynamics of sensory substitution in the congenitally blind and the perceptual qualia they confer. The fusiform face area differentiates soundscapes of faces within ~400ms, and primary visual cortices retain vertical vs. horizontal line orientation sensitivity within ~270ms. The functional utility of multisensory plasticity in visual rehabilitation is widespread and cost-effective.

Monday Afternoon Symposium Talks

Monday Symposium

2:00pm - 3:30pm

Room Danube

On the dynamics and rehabilitative power of multisensory plasticity

Van der Stoep, Nathan, Rowland, Benjamin

In the last few decades, it has become clear that the way the brain processes multisensory input is dependent upon the provided/available sensory input and the sensory experience with the world around us. It could be argued that this dependency is not only of great importance during development to establish a sensory processing strategy that allows for coherent multisensory representations, it also provides a basis for multisensory plasticity later in life. Our goal with this symposium is to advance our insights into the impact of sensory impairments and brain damage on multisensory processing during development and adulthood, and to demonstrate the wonderful opportunities the multisensory brain provides to rehabilitate patients with various sensory disabilities. Although many insights into these processes have been gained by researchers from the multisensory research community in previous years, our hope is to build upon their work and push the field even further to get a better understanding of the mechanisms driving multisensory plasticity. Not only to better understand the how and why but also to utilize this fundamental knowledge for rehabilitative purposes. The speakers in this symposium will present some of their latest findings regarding (1) the impact of sensory impairments (e.g. hearing loss, blindness) and brain damage on multisensory processing and multisensory brain plasticity, and (2) the utilization of multisensory plasticity mechanisms to rehabilitate unisensory and multisensory functions after sensory impairments.

Using multisensory training to restore sight in the blind

Rowland, Benjamin, Stein, Barry;
Wake Forest School of Medicine

Damage to visual cortex on one side of the brain commonly induces a profound blindness in contralesional space (hemianopia). In an animal model of this disorder, a lesion targeting all contiguous areas of unilateral visual cortex produces a permanent contralesional blindness. Fortunately, contralesional visual responsiveness can be rapidly restored by a multisensory exposure paradigm using spatiotemporally congruent visual-auditory pairs. The effectiveness of this technique appears to be constrained by the same spatial and temporal principles governing multisensory integration in midbrain superior colliculus (SC) neurons, which are believed to be a crucial circuit component that supports recovered contralesional visual processing. Interestingly, rehabilitated animals appear to have visual and multisensory processing capabilities that exceed expectations, including stimulus/noise discrimination and the ability to discriminate basic visual patterns. Rehabilitated animals also fail to show an expected bias towards visual stimuli in the ipsilesional field within a choice/competition paradigm, despite the asymmetry in the ability of the hemispheres to represent and process visual stimuli when visual cortex has been removed on one side. Multisensory enhancement in detection/localization is intact in the recovered field. These observations not only support the viability of multisensory training in relieving the most severe aspects of this sensory disorder, but raise important questions about the visual capabilities of circuits outside of the geniculostriate pathway.

Disruption and restoration of multisensory integration after mild acute asymmetric hearing loss

Van der Stoep, Nathan[1], Böing, Sanne[1], Van der Stigchel, Stefan[1], Versnel, Huib[2], Wallace, Mark[3];
[1]Utrecht University, [2]University Medical Center Utrecht, [3]Vanderbilt University

Our senses need each other, not only during the development of our sensory systems early in life, but also when our senses have matured. A large body of research has demonstrated that integrating information from different senses greatly enhances our perceptual abilities. Strikingly, little is known about how our senses work together when one of our senses is partially impaired. Asymmetric hearing loss (AHL) is a common sensory impairment that disrupts auditory localization and causes conflicting auditory and visual spatial estimates. In two studies, we investigated how AHL affects audiovisual integration during spatial orienting behavior, and how multisensory plasticity can be used to improve auditory localization and ultimately restore sensory unity. In the first study, we show that participants greatly benefit from multisensory with normal hearing and vision, but fail to integrate auditory and visual information to facilitate orienting behavior during acute AHL. Using two models of multisensory perception, we demonstrate that with AHL, saccade initiation is driven by independent sensory signals and participants overweigh visual information even more than expected given the unisensory reliabilities. In a second study, we show that distorted auditory localization can be significantly improved using multisensory exposure. The results indicate that these improvements are likely due to both remapping of binaural and reweighting of monaural cues after multisensory exposure. Overall, these findings indicate that even mild sensory impairments such as AHL can profoundly alter the way humans integrate sensory information, and that multisensory exposure can restore sensory unity by improving unisensory perception.

Development of multisensory integration, visuomotor recalibration, and auditory space perception in cataract-treated individuals

Senna, Irene, Piller, Sophia, Ernst, Marc;
Ulm University

We investigated the development of multisensory integration, sensorimotor abilities, and space perception in children and adolescents who suffered from congenital dense bilateral cataracts and were surgically treated only years after birth. Right after surgery, their sensorimotor and multisensory integration abilities were impaired. Similarly, their auditory space perception and mobility in the environment were defective, in accordance with the cross-calibration hypothesis, which suggests that vision may have a crucial role in calibrating spatial cognition in other modalities during development. With time after surgery, and thus experience, however, they developed multisensory and sensorimotor abilities and improved auditory space perception. Such an improvement appeared related to both post-surgical visual acuity and time-since-surgery. However, despite the improvement, cataract-treated individuals did not reach the level of sighted age-matched controls in some spatial tasks even a few years after surgery. We then investigated whether targeted audio-visuomotor training could boost such a recovery. Participants performed entertaining motor activities with devices associating audio-visual feedback to participants' body movements. After a short training (1-2 weeks), they improved in most tested spatial skills and in their mobility in the environment, even achieving the level of sighted controls in some tasks. The present findings show that, despite years of visual impairment, cataract-treated individuals retain considerable plasticity, and can develop multisensory, sensorimotor and spatial abilities after surgery. Such an improvement can be significantly enhanced by employing targeted training strengthening the association between a movement and its sensory counterpart.

Visual and crossmodal activation after sight restoration in humans

Röder, Brigitte[1], Dormal, Guilia[1], Sourav, Suddha[1], Shareef, Idris[2], Rajendran, Siddhart[2], Kekunnaya, Ramesh[3], Pitchaimuthu, Kabilan[1];
[1]University of Hamburg, [2]University of Hamburg, LV Prasad Eye Institute, [3]LV Prasad Eye Institute

Studying individuals who were born without pattern vision due to dense bilateral cataracts, which were subsequently removed, allows investigating sensitive periods in visual and multisensory brain development. A highly consistent finding in blind adults is a stronger auditory activation of visual brain regions compared to sighted individuals. To which degree crossmodal plasticity retracts after sight recovery and whether this relates to the responsiveness of visual brain regions to visual stimulation is yet unknown. The few existing brain activation studies either found no or a weak auditory related activity in visual cortex of sight recovery individuals. The present study used fast periodic visual and auditory stimulation, which elicits highly reliable visual and auditory steady evoked responses (SSVEP, SSVAEP), respectively. Sight recovery individuals both with a history of congenital (CC) and developmental (DC) cataracts were investigated after surgery and their data were compared to sighted controls (SC). While the SSVEPs at the visual stimulation frequency did not differ across groups, CC individuals showed reduced SSVEPs for the second harmonic. By contrast, stronger SSVAEP for the auditory stimulation frequency but not for the second harmonic were found over occipital cortex in CC individuals compared to the SC group. These results suggest that higher order visual processing is more impaired than bottom up driven visual activation after sight restoration. The results for auditory fast periodic stimulation are compatible with the idea of feedforward driven auditory activation in visual cortex of sight recovery individuals with a history of a congenital loss of pattern vision.

Hearing the visual rhythm and seeing the audio space: early cortical sensory responses in typical but not in blind and deaf individuals

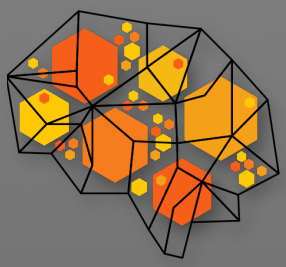
Gori, Monica[1], Amadeo, Maria Bianca[1], Bertonati, Giorgia[1], Pavani, Francesco[2], Campus, Claudio[1];
[1]Istituto Italiano di Tecnologia, [2]Istituto Italiano di Tecnologia, University of Trento, Centre de Recherche en Neuroscience de Lyon

The brain is capable of large-scale reorganization following sensory deprivation. The extent of such reorganization is not clear to date. Many works show that the visual modality is crucial to developing spatial representations, and the auditory modality is essential to creating temporal representations. Blindness and deafness are ideal clinical conditions to study the reorganization of spatial and temporal representations when visual or audio signals are not available. We recorded ERPs and psychophysical responses in 16 sighted and 16 blind participants while performing spatial and temporal audio bisection tasks, and in 12 hearing and 12 deaf participants while performing spatial and temporal visual bisection tasks. They perceived three sounds or lights and judged the spatial or temporal relative position of the second stimulus to the other two. Audio stimuli during spatial bisection elicited an ERP response in occipital areas in sighted but not in blind subjects. This response appeared 50-90ms after the second flash mimicking the C1 ERP component, usually elicited by visual stimuli. Visual stimuli during the temporal bisection elicited an ERP response in fronto-central and temporal areas in the typical hearing but not in deaf subjects. This response appeared 50-90ms after the second flash mimicking the N1a ERP component, usually elicited by auditory stimuli. Thus the primary cortices have a pivotal role in building high resolution and flexible spatial and temporal representations. These mechanisms are experience-dependent. Recent findings revealed that, in healthy adults, the task-specific organization of visual and auditory brain areas acts also within a multisensory framework.

Individual differences of brain plasticity in early visual deprivation and sight restoration

Striem-Amit, Ella;
Georgetown University

Early-onset blindness leads to reorganization in visual cortex connectivity and function. However, this has mostly been studied at the group-level, largely ignoring differences in brain reorganization across early blind individuals. In this talk, I will present resting-state functional connectivity (RSFC) findings in a large cohort of blind individuals that shows that reorganization is not ubiquitous, highlighting the important role for sensory experience during development in driving individual differences. Further, I will show that this variability is linked to postnatal life experiences. Building on these findings, I will discuss how variability in reorganization in the early blind may affect the capacity to benefit from sight-restoring treatment. Overall, our data highlight the diversity in brain plasticity and the importance of harnessing individual differences for fitting rehabilitation approaches for vision loss.



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International Multisensory Research Forum

ULM 2022

Monday Afternoon Symposium Talks

Monday Symposium

2:00pm - 3:30pm

Room Lago

Twenty years of the Sound Induced Flash Illusion: What have we learnt?

Hirst, Rebecca J, Setti, Annalisa, Newell, Fiona

In the Sound-Induced Flash Illusion (SIFI) presenting a single flash with two beeps results in the perception of two flashes. Now, 20 years since its discovery, over 100 studies have used the SIFI and several lines of evidence highlight it as a promising tool to assess the efficiency of multisensory integration. Recently, the SIFI has been incorporated into a large-scale longitudinal study on ageing (The Irish Longitudinal Study on Ageing, TILDA); it is therefore more important than ever to assess the efficacy of the SIFI as a research and clinical measure. In this Symposium, we discuss existing literature on the SIFI and cover four important themes: the theoretical basis of the SIFI, the neural origins of this illusion, changes in SIFI across the lifespan, and the use of SIFI to assess pathological processes in clinical conditions. Convergent findings show that this illusion results from optimal integration and directly probes the temporal dynamics of multisensory processing. The SIFI originates from early modulation of visual cortex by auditory and multisensory regions, possibly indicating GABAergic mediated cortical excitability in these areas. The illusion provides direct insight into developmental narrowing and age-related widening of the Temporal Binding Window. Finally, the multisensory mechanisms measured by the SIFI have been useful in mapping pathological processes in various clinical conditions. The SIFI enables measurement of multiple effects, fission and fusion, an open question is what processes give rise to these differing illusions. In addition to discussing its application, speakers will share what they have learnt and recommendations for future researchers moving forward with this paradigm.

Sound-induced Flash Illusion as an Example of Crossmodal Interactions in Perception

Shams, Ladan;
UCLA Department of Psychology, UCLA Department of BioEngineering, UCLA Neuroscience Interdepartmental Program

Traditionally, humans were considered “visual animals,” where vision dominates other senses in how we perceive the world. Sound-induced flash illusion (SIFI) contradicts the long-standing notion of visual dominance, and as such, it surprises and amuses observers. In this talk, I will review evidence from behavioral and neuroimaging studies that have established that SIFI reflects crossmodal interactions at a perceptual level, as opposed to a cognitive level. I will also review results showing that this type of interaction is not limited to flashes and beeps; it is an integration phenomenon that generalizes to other combinations of sensory modalities and sensory conditions, and follows general principles of probabilistic inference that govern other illusions and other perceptual phenomena. In this context, I will discuss the do’s and don’ts of analyzing and interpreting the behavioral data in this experimental paradigm in terms of integration versus unisensory processing components. The same guidelines also apply to interpretation of behavioral data in other multisensory illusions.

Solving the binding problem in the sound-induced flash illusion: computations and neural mechanisms

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

Transforming the barrage of sensory signals into a coherent percept relies on solving the binding problem – deciding whether signals come from a common cause and should be integrated or, instead, be segregated. Combining psychophysics, Bayesian modeling and EEG we investigated how the brain solves the binding problem in the sound-induced flash illusion. Our results suggest that the brain arbitrates between sensory integration and segregation consistent with the principles of Bayesian Causal Inference by dynamically encoding multiple perceptual estimates. Initially, the brain represents the number of flashes and beeps mostly independently (i.e. segregation). Later, it combines signals weighted by their reliabilities and task-relevance into multisensory estimates that take into account the world’s causal structure as predicted by Bayesian Causal Inference. Crucially, prestimulus oscillatory alpha power and phase - but not frequency - influence observers’ tendency to bind signals across vision and audition and experience the sound induced flash illusion.

The neural basis of the Sound-Induced Flash Illusion

Keil, Julian;
Biological Psychology, Christian-Albrechts-University Kiel, Germany

In the sound-induced flash illusion paradigm, we receive concurrent auditory and visual information. This information is then processed and integrated to a subjectively coherent perception, which – in case of incongruent auditory and visual information - can result in the illusion. Therein, the multisensory integration requires the coordinated activity of distant cortical areas, and the state of the brain can influence this process. Key mechanisms implicated in multisensory integration include local neural oscillations and functional connectivity between distant cortical areas. A number of studies show that activity in primary sensory cortices is related to the perception of the sound-induced flash illusion. In addition, higher-order processing stages play a critical role in illusion perception. Moreover, changes in functional connectivity in networks between primary and higher-order stages shapes multisensory integration, and there is now robust evidence that ongoing neural activity in these networks influences the perception of forthcoming audiovisual stimuli. Finally, it is now emerging that neural oscillations in distinct frequency bands reflect different mechanisms of multisensory integration, which may be influenced by GABAergic mediated cortical excitability. Taken together, findings collected over the past twenty years point to a multisensory integration process in the sound-induced flash illusion involving multiple processing stages and distributed functional connectivity networks.

The fission and fusion illusions compared across modalities and development

Shore, David I[1], Chen, Yi-Chuan[2], Stanley, Brendan M[1], Lewis, Terri L[1], Maurer, Daphne[1];
[1]McMaster University, Canada, [2]Mackay Medical College, Taiwan

The fission and fusion illusions provide putative indexes of multisensory integration: larger illusions are attributed to stronger integration. Here we tested children aged 7, 9, 11, and 13 years in three modality pairings: sound-induced and tap-induced visual illusions, and sound-induced tap illusions. The magnitude of illusion can be computed by subtracting accuracy on congruent trials from accuracy on incongruent trials: for fission, accuracy in the one-flash–two-beep condition from accuracy in the one-flash–one-beep condition; for fusion, accuracy in the two-flash–one beep condition from accuracy in the two-flash–two-beep condition. That metric suggests that the magnitude of the illusions decreases into early adolescence, but reaches adult levels at different ages depending on the illusion and on the modality pairing. However, these analyses do not consider baseline improvements in detection of a discontinuity—indexed by accuracy in the no distractor condition. Signal detection analysis reveals significant unimodal improvement in sensitivity for all modalities tested. This improvement accounts for most of the change in the illusory conditions. For the sound- and tap-induced flash illusion, these visual changes account for the developmental reductions in the size of the illusions. However, for the sound-induced tap illusions, there are developmental changes in the illusions over and above changes in unimodal sensitivity. In addition, there are some subtle changes in bias with age in all modalities tested. Discussion will focus on the implications of these differences in developmental trajectories for understanding the mechanisms of the fission and fusion illusions.

The Sound-Induced Flash Illusion in The Irish Longitudinal Study on Ageing: Links with cognitive performance

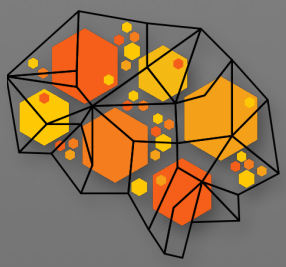
Hirst, Rebecca J[1], Setti, Annalisa[2], Kenny, Rose Anne[3], Newell, Fiona N[1];
[1]School of Psychology and Institute of Neuroscience, Trinity College Dublin, Ireland, [2]School of Applied Psychology, University College Cork, Irelands, [3]The Irish Longitudinal Study on Ageing, Trinity College Dublin, Ireland

In 2014, The Irish Longitudinal Study on Ageing (TILDA) became the first large-scale, nationally representative study in the world to include a measure of multisensory function within its healthcare assessment. This measure was derived from a task based on the Sound-Induced Flash Illusion (SIFI), which was completed by 4014 older adults during wave 3 of TILDA, alongside an extensive battery of physical and cognitive assessments. In our talk we will provide an overview of what has been learned from this invaluable dataset to date, with a particular focus on findings supporting a link between cognitive function and multisensory integration in ageing. Overall, the results from TILDA suggest SIFI susceptibility increases with age, is stronger in females and is manipulated by the relative reliability of visual and hearing ability. Greater SIFI susceptibility is associated with poorer performance on tests of Executive Function, Memory but not Processing Speed and has also been observed in slower walkers. Importantly, the association between SIFI susceptibility and cognitive ability remains significant even when considering unisensory measures of vision and hearing. In sum, the results of a short SIFI-based task have proved fruitful in understanding changes in multisensory function in ageing, as well the consequences these changes may have on behaviour. Moreover, the findings point towards multisensory integration as an important sensory biomarker of cognitive performance in ageing. The next wave of TILDA healthcare assessments will provide longitudinal data on SIFI susceptibility and will enlighten whether SIFI is predictive of cognitive decline, in addition to current cognitive performance.

Double Flash Illusion as a tool to investigate the abnormal temporal dynamics of multisensory processing in schizophrenia and schizotypy

Ferri, Francesca[1], Costantini, Marcello[2], Romei, Vincenzo[3];
[1]Department of Neuroscience, Imaging and Clinical Sciences, University of Chieti-Pescara, Chieti, Italy, [2]Department of Psychological, Health and Territorial Sciences, University of Chieti-Pescara, Chieti, Italy, [3]Centre for studies and research in Cognitive Neuroscience, Universita’ di Bologna, Cesena, Italy

The coherent experience of the self and the world, typically altered in schizophrenia spectrum disorders, depends on the ability to integrate sensory information. Optimal temporal integration between the senses is mediated by oscillatory properties of neural activity, as recently confirmed by studies conducted in healthy individuals using the double flash illusion (DFI). These studies showed that the temporal window of the auditory-induced DFI (aDFI) is predicted by the speed of individual occipital alpha oscillations, while the tactile-induced DFI (tDFI) is predicted by the speed of individual occipital beta oscillations. Based on this evidence, and according to the idea of a psychosis continuum, we used the DFI to test the hypothesis that high schizotypal traits in the general population may be associated to reduced temporal sensitivity to multisensory events and incoherent perception, akin to schizophrenia. Using the aDFI, we showed higher proneness to illusions in individuals with high schizotypal traits, which was fully explained by a significantly reduced temporal sensitivity to integrate sensory information. In a separate study, using the tDFI, we found individuals with higher schizotypal traits to have wider temporal window of illusion, which was associated to slower beta waves. All in all, these results suggest that the DFI is a sensitive tool to reveal the reduced temporal sensitivity in multisensory processing, and the associated specific changes of oscillatory patterns, which might constitute early markers for psychosis proneness, at the behavioural and neural levels.



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International Multisensory Research Forum

ULM 2022

Monday Afternoon Symposium Talks

Monday Symposium

4:00pm - 5:15pm

Room Danube

(A)typical Multisensory Processing: from Bodily Self-Consciousness to Social Interactions

Gillmeister, Helge, **Auvray, Malika**

When I walk, sing, fall and feel pain, these experiences are fundamentally tied to a sense of self bound to my body, as a unitary and distinct entity. Bodily self-consciousness lies at the heart of our experiences, anchoring our disparate perceptions, emotions, thoughts, and actions into a unitary whole. The capacity to integrate self-related information across multiple sensory channels is fundamental to building a cohesive representation of our body and environment. Multisensory integration scaffolds both our subjective experience of being present here and now, and our successful navigation in a complex physical and social world. Alterations of this capacity are reported in several clinical conditions, significantly affecting people's personal and social life.

Our symposium brings together novel theoretical insights and empirical findings from experimental psychology and cognitive neuroscience in order to examine i) the mechanisms underlying (a)typical multisensory integration of self-related information processing and ii) their effect on bodily self-consciousness and socio-emotional understanding. Specifically, we focus on:

1) perspective-taking flexibility as a function of sensory parameters (vision and proprioception) and social cognition abilities (Malika Auvray)

2) sensory parameters of body stretching illusions in healthy participants with relevance to chronic pain (Catherine Preston)

3) atypical multisensory integration and emotional processing in Depersonalisation (Helge Gillmeister)

4) disturbed multisensory interoceptive and self-referential processing in Eating Disorders (Megan Klabunde)

5) disrupted sensorimotor experiences and bodily self-consciousness after right hemisphere stroke (Louise Kirsch)

Together, our talks contribute to a coherent picture of how interactions between our bodily senses and the world around us generate selfhood both in health and disease. Specifically, we delineate how our contingent multisensory bodily experiences are critical for a precise, integrated subjective sense of self as distinct from the world around us, and the hopes this understanding may offer for individuals whose selves are experienced as distorted, disconnected or inflexible.

Juggling self-centred and other-centred perspectives: influence of sensory deficits and social cognition

Auvray, Malika;
Institut des Systèmes Intelligents et de Robotique, CNRS, Sorbonne Université, Paris, France

Different spatial perspectives can be taken on tactile stimuli displayed on the body surface. These stimuli can be mentally projected out of the body surface, as if they were coming from external objects or thought as being localised on the body. These possible projections answer different requirements. Indeed, on the one hand, integrating different stimuli, across sensory modalities, from a self-centred perspective is crucial for the unity of the self. On the other hand, understanding external space and communicating spatial knowledge with others requires adopting other-centred perspectives. How do we juggle these two requirements? In this talk I will review the set of studies we conducted investigating how people differ in the spatial perspectives they naturally adopt. In addition, the graphesthesia task we developed allows investigating people's ability to flexibly change spatial perspectives, a measure that is often neglected by other perspective-taking tasks. In particular, I will highlight how perspective-taking varies as a function of sensory parameters (in particular visual and proprioceptive impairments) and social cognition (such as social intelligence and anxiety).

Neural correlates of multisensory and visual only finger stretching: implications for treatments of chronic pain

Preston, Catherine;
Department of Psychology, University of York

Multisensory body illusions elicit a temporary experience of changes to the perceived state of the body using multisensory integration. For example, illusory finger stretching involves seeing an image of your finger elongating at the same time as feeling a congruent tactile sensation of pulling on the skin, which elicits a vivid illusion as if your finger is really stretching. Recent research has implicated stretching illusions in treatments for chronic pain, but how these illusions work to ameliorate pain is unknown. Most theories concerning the mechanisms of body illusions incorporate a combination of bottom-up multisensory integration and top-down cognitive processing. However, recent research has found that it is possible to elicit body illusions using vision alone. This study examines neural correlates of multisensory and vision only finger stretching illusions using EEG. Healthy participants undergo multisensory, vision only and asynchronous (i.e seeing stretching whilst feeling pushing) finger stretching whilst recording EEG signals and subjective experience of illusion strength. Pilot behavioural data suggest that multisensory integration is required to elicit a strong stretching illusion, but that vision only finger stretching invokes stronger subjective illusions compared to asynchronous stimulation. How these behavioural effects relate to EEG signals will be discussed in relation to mechanisms of body ownership and potential mechanisms of illusion-based analgesia.

Electrophysiological studies of multisensory and emotional body perception in Depersonalisation

Gillmeister, Helge;
Department of Psychology and Centre for Brain Science, University of Essex, UK

Electrophysiological studies can reveal the underlying cortical dynamics of atypical perceptual and cognitive processes in depersonalisation. Here I present a series of studies investigating early perceptual and late cognitive mechanisms underlying (self-)face recognition, emotional priming and bodily resonance in individuals with transient and chronic depersonalisation. Study 1 shows reduced visuotactile integration for the self-face at early perceptual stages in individuals with high vs. low levels of transient depersonalisation and less self-other differentiation at late cognitive stages. Study 2 presents evidence for dysfunctional emotional face processing and atypical emotional face/voice priming on visuotactile integration in individuals with high levels of transient depersonalisation. Together these results suggest that altered visuotactile integration for stimuli on one's own body may result from abnormal emotional information processing associated with the self and others.

Disturbed cognitive and multisensory interoceptive processing in Eating Disorders: Evidence from a Bayesian meta-analysis of fMRI studies

Klabunde, Megan;
Department of Psychology and Centre for Brain Science, University of Essex, UK

Studies suggest that aberrant interoception contributes to symptoms in both Anorexia (AN) and Bulimia (BN) Nervosa. Typically, fMRI studies probe one interoceptive sense, revealing mixed results when attempting to elucidate neural mechanisms underlying disturbed interoception in eating disorders. We sought to address heterogeneity across interoceptive senses and eating disorder subtypes to directly compare brain activation clusters. We conducted the first known study to examine clinical disorders using unsupervised Bayesian author-topic-model fMRI meta-analysis procedures with activation likelihood estimation (ALE) coordinates for 38 whole-brain fMRI studies of AN and BN compared to healthy control participants (HC). Two components best fit the data. Component one was associated with the default mode network (DMN), activating the cuneus, precuneus, anterior cingulate, and medial frontal and cingulate gyrus; this cluster was associated with tasks underlying cognitive control, passive set shifting, and self-referential thought. Component two was associated with multisensory interoceptive processes (taste, touch, pain, breathing load); activation included sensory processing and multisensory integration and regulation regions such as the claustrum, insula, superior temporal gyrus and cerebellum. There were differences in activation within the DMN and multisensory integration between HC and ED groups across several studies. This provides novel data on how overall brain activation patterns differ in eating disorders during tasks probing interoception and new methods for brain-based studies of multisensory processing. Our results suggest abnormal activation of brain regions underlying the DMN and bottom-up interoceptive processes in EDs, indicating the need for treatments that aim at self-referencial focus and sensory processing.

Disruptions of sensorimotor experiences and bodily self-consciousness after right hemisphere stroke

Kirsch, Louise;
Integrative Neuroscience and Cognition Center (INCC), Université Paris Cité, Paris, France

In order to interact adequately in a social world, we first need to have a unified perception of ourselves. In this talk, I will present the results of a series of neuropsychological studies we conducted in right hemisphere stroke patients. These patients suffer from different sensory deficits that might result in difficulties in integrating multisensory signals, such as touch, and updating their bodily self representation. In particular, right-hemisphere stroke can impair the ability to recognize one's contralesional body parts as belonging to one's self and the ability to update sensorimotor abilities. In a first study, we showed that the right insula is necessary for affective touch perception and awareness. A second study revealed the importance of affective touch as it can increase the sense of body-part ownership following right-hemisphere stroke, potentially due to its unique role in the multisensory integration processes that underlie the sense of body ownership. Finally, in a third study, we showed how anosognosia for hemiplegia, or the lack of awareness for one's paralysis following right hemisphere stroke, can be explained by abnormalities in the relative uncertainty ascribed to prior beliefs versus sensory information in different contexts. Taken together, these neuropsychological studies highlight the importance of multisensory integration to get a unified and updated sense of self.

Monday Afternoon Symposium Talks

Monday Symposium

4:00pm - 5:15pm

Room Lago

New insights on multisensory brain organization from MVPA to high field fMRI

Gaglianese, Anna; Murray, Micah M.

In the last years multisensory research has changed our knowledge about brain functional development and specialization. Thanks to human brain imaging techniques such as fMRI and EEG, neuronal recordings via intracranial measurements and advanced signal analysis approaches we are starting to disentangle the multisensory nature of primary and higher order brain regions. This symposium brings together emerging techniques and signal analysis approaches to explore the mechanisms of multisensory integration in the human brain. Speakers of this symposium will inform us about the brain activation patterns underlying the convergence and integration of information from different senses within low- and high-level cortices. The research highlighted in this symposium will take advantages from advanced signal analysis techniques such as multivariate pattern analysis and population receptive field mapping to characterize the multisensory nature of brain regions canonically described to be highly specialized to respond only to distinct sensory information. Furthermore, brain measurements undertaken with ultra-high field MRI at 7T will shed new lights on the multisensory and attentional mechanisms that regulate sensory processing at the spatial scale of neuronal ensembles. These findings will have an impact on how the brain reorganize in case of a sensory loss and on clinical applications such as rehabilitation programs that aim at restoring function through other sensory modalities.

Distinct sensory representations in supramodal networks: Topographic maps representing haptic numerosity

Hoffstetter, Shir[1], Cai, Yuxuan[1], Harvey, Ben M.[2], Dumoulin, Serge O.[1];
[1]Spinoza Centre for Neuroimaging, Amsterdam, The Netherlands, [2]Department of Experimental Psychology, Utrecht University

Recent studies found topographic maps in the association cortices that represent features of cognitive perception such as numerosity, item size and time1–4, suggesting that topography is a common principle of brain organization. However, the maps described so far are driven by the visual system. Using numerosity mapping we ask whether topographic maps of cognitive perception are (in)dependent of sensory modality. Here, we test: (1) whether numerosity topographic maps can also be driven by other sensory modalities, specifically by the haptic system; (2) whether these topographic maps converge into a supramodal numerosity representation or remain modality-specific. We investigated these questions by measuring the neural responses elicited by haptic numerosity stimuli. We placed varying numbers of plastic spheres (1 to 7) in the hands of participants while collecting ultra-high field (7T) fMRI data. Participants were asked to explore the spheres, but no numerosity judgments were required. The fMRI responses were summarized using a numerosity-selective population receptive field (pRF) model1,5. We found evidence of haptic numerosity selective neural populations exhibiting topographic organization. At the macroscale we found areas that respond to the numerosity of both visual and haptic stimuli. However, the visually-driven and the haptically-driven topographic maps are distinct: neural populations selective for numerosity can fall within the same cortical location but their response depend on the modality of input. Conceivably, these overlapping but distinct numerosity-tuned neural populations may allow for cross-modal integration of numerosity information. Thus, supramodal cognitive networks may be represented by overlapping yet distinct sensory-dependent topographic maps.

Impact of blindness onset on the representation of sound categories in occipital and temporal cortices

Mattioni, Stefania, Collignon, Olivier;
1 Institute for research in Psychology (IPSY) & Neuroscience (IoNS), Louvain Bionics, Crossmodal Perception and Plasticity Laboratory - University of Louvain (UCLouvain), Louvain, Belgium

Using a combination of uni- and multi-voxels analyses applied to fMRI data, we comprehensively investigated how early and late-acquired blindness impact on the cortical regions coding for the deprived and the remaining senses. First, we show enhanced univariate response to sounds in part of the occipital cortex of both blind groups that is concomitant to reduced auditory responses in temporal regions. We then reveal that the multivoxel encoding of the “human voice” category (when compared to animals, manipulable objects and big objects or scenes) is reduced in those temporal and enhanced in those occipital regions in both blind groups. Importantly, we additionally show that blindness does not affect the encoding of the acoustic properties of our sounds (e.g. pitch, harmonicity) in occipital and temporal regions but instead selectively alter the categorical coding of the voice category itself. These results suggest a functionally congruent interplay between the reorganization of occipital and temporal regions following visual deprivation, across the lifespan.

Voxel-wise modelling reveals sound envelope representation in primary visual cortex

Setti, Francesca[1], Handjaras, Giacomo[1], Bottari, Davide[1], Leo, Andrea[2], Diano, Matteo[3], Bruno, Valentina[3], Tinti, Carla[3], Cecchetti, Luca[1], Garbarini, Francesca[3], Pietrini, Pietro[1], Ricciardi, Emiliano[1];
[1]Molecular Mind Lab, IMT School for Advanced Studies Lucca, Lucca, Italy, [2]Molecular Mind Lab, IMT School for Advanced Studies Lucca, Lucca, Italy ; Department of Translational Research and Advanced Technologies in Medicine and Surgery, University of Pisa, Pisa, Italy, [3]Department of Psychology, University of Turin, Turin, Italy

The processing of multisensory information is based upon the capacity of brain regions, such as the superior temporal cortex (STC), to combine shared information across modalities. However, to what extent multisensory processing is innately present in the human brain, or rather depends on experience remains an open debate. In three fMRI protocols we used Inter-Subject Correlation (ISC) analysis to investigate whether the representation of coherent auditory and visual events does require any prior audiovisual experience to develop and function. An audiovisual and two coherent unimodal (visual and auditory) versions of the 101 Dalmatians movie were employed. Brain activity was acquired using 3T fMRI in three groups of typically developed (TD) individuals, presented with either the audiovisual (n=10), the visual (10) or the auditory (10) movie and two groups of sensory deprived (SD) participants (9 congenitally blind and 9 congenitally deaf). The STC was synchronized across auditory and visual streams both in TD and SD groups, indicating that multisensory areas develop irrespectively from audio-visual experiences. An innovative model-mediated version of ISC also assessed that the synchronization across senses was primarily mediated by low-level perceptual features. Equally, when characterizing the temporal dynamics of the synchronization, an identical modality-independent topographical organization was demonstrated within the STC of all groups. The present findings favor the hypothesis that the STC is endowed at birth with a functional scaffolding to yield basic audiovisual processing. Conversely, the refinement of more complex audiovisual skills requires a full multisensory experience.

Auditory enhancement of visual completion

Gaglianese, Anna[1], Murray, Micah[2];
[1]The Laboratory for Investigative Neurophysiology (The LINE), Department of Radiology, University Hospital Center and University of Lausanne, Lausanne, Switzerland, [2]Sensory, Perceptual and Cognitive Neuroscience Section, Center for Biomedical Imaging (CIBM), Lausanne; Ophthalmology Service, Fondation Asile des Aveugles and University of Lausanne, Switzerland

Vision in everyday life must reconcile poor or noisy conditions in order to generate correct perceptions of the world. The visual system must infer the information that is absent or unavailable, sometimes resulting in perception of borders when contrast gradients are missing. The perception of such illusory contours (IC) is an evolutionarily conserved process and plays a key role in the processing of complex visual scenes Until recently, IC processes were considered exclusively visual in nature and presumed to be unaffected by information from other senses. In recent years, there has been an increasing interest in the possible role of multisensory influences on IC processing and shape completion. Here we used high-resolution 7T fMRI to characterize the organization of the BOLD-activity when presenting a sound together with an illusory shape. We found that sounds enhance accuracy in V2 and V3 during the processing of IC, but not control conditions that do not result in visual completion. MVPA results suggests that these areas have an active role in decoding the presence of IC only when sound was present, highlighting the role of multisensory processing in benefiting mid level visual function.

Re-discovering the lost medial wall Penfield homunculus and a novel homunculus in the insula: putative multisensory links between body and mind?

Zeharia, Noa[1], Hoffstetter, Shir[2], Flash, Tamara[3], Amedi, Amir[4];
[1]The Baruch Ivecher Institute for Brain, Mind & Technology, IDC Herzliya, 4610101, Israel. Department of Computer Science and Applied Mathematics, Weizmann Institute of Science. Hebrew University of Jerusalem, Jerusalem 91220, Israel, [2]The Baruch Ivecher Institute for Brain, Mind & Technology, IDC Herzliya, 4610101, Israel. Spinoza Centre for Neuroimaging, [3]Department of Computer Science and Applied Mathematics, Weizmann Institute of Science, Rehovot 76 100, Israel, [4]The Baruch Ivecher Institute for Brain, Mind & Technology, IDC Herzliya, 4610101, Israel. Department of Computer Science and Applied Mathematics, Weizmann Institute of Science

In 1954, Penfield and Jasper's findings based on electric stimulation of epileptic patients led them to hypothesize that another homunculus might be present in the precuneus but emphasized that the data was ambiguous and further studies needed. In the decades that followed, their prediction was neglected. Here we used a periodic experimental design in which 16 subjects moved 20 body parts. We found an anterior-to-posterior, dorsal-to-ventral, toes-to-tongue gradient of the body. When inspecting body part specific functional connectivity, we found differential connectivity patterns for the different body parts to the primary and secondary motor areas, parietal and visual areas, and a shared connectivity to the extra-striate body area. We suggest that a whole-body gradient with a multisensory role can be found in the precuneus. Its exact role and relations to the other known functions of the precuneus such as self-processing, motor imagery, reaching, visuo-motor and other body-mind functions will be discussed. This homunculus joins a family of homunculi discovered by our lab (e.g. Zeharia et al. PNAS 2012; JN 2015, 2019). The most relevant in the context of the current work is the Insula homunculus – another center for embodied cognition and important part of the limbic system

Monday Evening Posters

Monday Posters

7:00pm - 8:30pm

Foyer

A new Virtual Reality based paradigm to test sensory-motor plasticity in multisensory interactions

Girondini, Matteo; Montanaro, Massimo; Gallace, Alberto
University of Milano Bicocca, Italy;

The body representation in the brain is affected by continuous changes as we interact with the world. The terms body schema defines a neural representation of the body that is continuously updated with movement . The interactions between the body and external space contribute to sustain a neural 'body matrix' that is susceptible to large modulations and can integrate extracorporeal objects (e.g., artificial limbs and bodies). Some clear examples of such plasticity regard the integration of tools within the body schema after prolonged use or the rubber hand illusion, due to synchronous visuo-tactile interactions. The mechanisms at the basis of these phenomena depends on the principles of multisensory integration, in particular between visual, tactile, proprioceptive and motor signals . However, we might ask what happen in case of prolonger mismatches between these signals in the brain system. These mismatches are not always simple to be realized in the real world, but virtual reality offer now a new tool to push the limits of human adaptations to multisensory interactions within the environment. In this work, we presented a new paradigm to investigate the effect of multisensory incongruency on sensory-motor brain areas by means of Virtual Reality, microcontroller-driven tactile stimulators, and TMS (TMS-MEP). By using these devices, it becomes possible to dissociate the sensory-motor input provided by vision from the input coming from tactile and proprioceptive afferences during action performance. More specifically, in our new paradigm we create multisensory incongruences between tactile and visual feedback regarding the position of virtual objects during a tool-based manipulation task. TMS-MEP over the motor cortex is used to investigate the effects of these mismatches on neural plasticity. The preliminary results coming from this research may offer interesting insights into the mechanisms at the basis of multisensory integration in virtual tool control.

A combined neurophysiological and neuroimaging approach to explore the cortico-brainstem interaction in multiple sclerosis.

Biggio, Monica[1]; Bonzano, Laura[1]; Brichetto, Giampaolo[2]; Bove, Marco[1]
[1]University of Genoa, Italy; [2]Multiple Sclerosis Italian Foundation, Genoa, Italy;

Hand blink reflex (HBR) is a subcortical reflex consisting in a blink response following a peripheral stimulation. HBR, differently from other reflexes like the trigeminofacial blink reflex (TBR), is modulated by the proximity of the stimulated hand to the face. Despite brainstem dysfunctions are very common in Multiple Sclerosis, HBR has never been investigated in people affected by this disease (PwMS). The study of HBR in PwMS could allow investigating the activity of the cortico-bulbar circuits and provide information related to functionality of the cortical-brainstem pathways. Aim of this work was to investigate HBR response in PwMS, its relationship with the motor and associative cortical regions and its possible alteration due to the disease. 10 PwMS with relapsing-remitting MS and 10 healthy controls underwent diffusion MRI scan, with special focus on the corona radiata (CR), and possible brainstem circuits abnormalities were evaluated by means of TBR and HBR recording. HBR and TBR were recorded from the orbicularis oculi muscles bilaterally and evoked by administering transcutaneous electrical stimuli to the median nerve or to the supraorbital branch of the trigeminal nerve, respectively. HBR was elicited bilaterally with the stimulated hand of the subject kept near and far from the face. Some people of PwMS group showed altered TBR responses, according to the literature's standard. HBR responses could also be impaired in PwMS, specifically some subjects did not shown the modulation due to the hand position with respect to the face. PwMS showed less functional anisotropy in all tracts of CR. TBR and HBR are impaired differently and should be mediated by different circuits. The alteration in HBR modulation could represent an impaired transfer of information between cortical areas and brainstem circuits. This finding can be supported by the reduced functional anisotropy in the corona radiata.

Intermodal attention influences early somatosensory processing in the human spinal cord

Amin, Mohammed Istiaque[1]; Azañón, Elena[1,2]; Deliano, Matthias[1]; Eimer, Martin[3]; Stenner, Max-Philipp[1,2,4]
[1]Leibniz Institute for Neurobiology, Magdeburg, Germany; [2]Otto von Guericke University Magdeburg, Germany; [3]Birkbeck, University of London, UK; [4]Center for Behavioral Brain Sciences, Magdeburg, Germany;

Does attention operate at the level of the human spinal cord? Functional magnetic resonance imaging (fMRI) has revealed decreased spinal cord responses to pain during distraction. However, due to its low temporal resolution fMRI cannot dissociate between an effect on early feedforward processing, or on later feedback responses. We recorded spinal evoked potentials via neck electrodes in response to non-painful electric stimulation of the median nerve during a sustained, intermodal attention paradigm. We presented a train of median nerve stimulation, in parallel to a train of auditory beeps, each consisting of stimuli predominantly separated by irregular, i.e., inconsistent, inter-stimulus intervals. Participants were asked to detect transient temporal regularities (four to five consecutive stimuli presented with regular, i.e., constant, inter-stimulus intervals) in one sensory modality while ignoring the other. Behavioral responses as well as somatosensory evoked potentials in scalp electroencephalography (EEG) confirmed that participants were shifting attention to the currently task-relevant modality. Importantly, we also found attentional modulation of the amplitude of early somatosensory evoked potentials recorded via neck electrodes, at around 8-13 ms, pointing to a spinal locus. Surprisingly, and in contrast to scalp EEG, we found lower amplitudes of evoked potentials in neck EEG when median nerve stimulation was task-relevant. The effect was most pronounced on the right side of the neck, contralateral to stimulation. We are currently testing a second cohort of participants to replicate the effect, and further examine its laterality.

Neural speech tracking in the absence of visual input: Dark listening

Bednaya, Evgenia[1]; Mirkovic, Bojana[2]; Berto, Martina[1]; Ricciardi, Emiliano[1]; Martinelli, Alice[1]; Federici, Alessandra[1]; Debener, Stefan[2]; Bottari, Davide[1]
[1]IMT School for Advanced Studies Lucca, Italy; [2]University of Oldenburg, Germany;

Neural activity synchronizes to amplitude modulations of continuous speech. Entrainment, or envelope tracking, is typically observed within the language network, modulated by low-level acoustic features, high-level meaningful linguistic units, and engagement. Recent evidence showed that visual cortex may contribute to speech envelope tracking, but the role of such involvement remains unclear.

Fifteen blindfolded participants listened to semantically meaningful or meaningless stories, in quiet or embedded in multi-talker babble noise. To assess entrainment, we used linear mapping between EEG and corresponding stimuli to estimate temporal response function (TRF) to speech envelope. We tested (1) low-level acoustic effects by contrasting TRFs to stories in quiet vs. in noise and (2) high-level linguistic effects by contrasting TRFs to meaningful vs. meaningless stories, both embedded in noise. To understand the origin of such effects, we performed source modeling of TRFs, focusing on the visual cortex.

Results showed that envelope tracking was enhanced and delayed for speech embedded in noise as compared to quiet, providing further evidence that entrainment is affected by low-level features and can represent a mechanism to boost comprehension in noise. When meaningless stories were presented TRFs displayed facilitated latencies and reduced amplitudes of early peaks, evidence of higher-level semantic effects. Source modeling showed that entrainment to speech envelope engages wide networks beyond the auditory cortex, especially as signal-to-noise ratio (SNR) decreases. In the absence of retinal input, the visual cortex participates in envelope tracking of continuous speech. While no clear influence of semantic content was found, the magnitude of such entrainment was affected by low-level speech features. A decreased SNR level dampened visual cortex response, suggesting suppression mechanisms in challenging listening conditions.

These findings show low-level acoustic and high-level linguistic effects on envelope tracking, involving broad networks of activation, and provide evidence of visual cortex's role in entrainment to continuous speech.

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Some historical data on multisensory processes

Gonzalo-Fonrodona, Isabel[1]; Porras, Miguel A.[2]
[1]University Complutense of Madrid, Spain; [2]Technical University of Madrid, Spain;

In the context of current research on multisensory processes, we deal with an early and insufficiently known quantitative research conducted by Gonzalo presented in the book "Dinámica Cerebral", Vol. 1 (1945), Vol. 2 (1950), and the article in Trab. Inst. Cajal Investig. Biol., XLIV, 95-57 (1952) [Open Access editions http://hdl.handle.net/10347/4341 (2010) in Spanish, and https://eprints.ucm.es/id/eprint/63730/ Vol. 1 (2021) and https://eprints.ucm.es/30931/ (2015) in English]. Gonzalo characterized a multisensory syndrome associated with a left parieto-occipital lesion in the angular gyrus near the end of the posterior intraparietal sulcus. All sensory systems were affected with bilateral symmetry. He studied the improvement of the perception of a stimulus by the facilitation provided by another stimulus of the same or another sensory system, and especially of the motor system. The improvement follows power laws with the intensity of the stimulus to be perceived or with the intensity of the facilitating stimulus. Muscular effort was particularly efficient as a facilitating action. In this way, the pathological perception of tilted or inverted visual image, and also inverted tactile localization, were studied in detail, as well as other functions. It was also shown that the greater the functional impairment, or the weaker the intensity of the stimulus to be perceived, the more efficient is the facilitating stimulus, this being related to the inverse effectiveness rule. The observations were interpreted according to a dynamic and unitary conception of the brain based on the laws of nervous excitability and on functional cortical gradients. A scaling factor would relate the normal brain system to that of this syndrome, which would explain that different functions are differently affected following allometric laws inherent to a dynamic system.

Managing Motion Sickness in Head-Mounted VR

Jin, Christina Yi; van Wassenhove, Virginie
CEA, France;

Virtual Reality (VR) is a simulated experience through computer-generated graphics, sound, sensory feedback, etc. The last decade has witnessed the boost of VR technology for entertaining, educational, and therapeutical purposes. Nevertheless, the frequently reported side effect of the VR devices, namely motion sickness or cybersickness, poses some safety concerns and limits the promotion of VR products. In this study, we review lab evidence of motion sickness in head-mounted VR. We first summarize the behavioral, physiological, and neural markers. In addition, we propose three ways to reduce or prevent VR motion sickness in a lab setting: (1) Designing a motion sickness friendly task; (2) Selection of participants based on their vulnerability to motion sickness; (3) Training to increase participants' resistance to motion sickness. We think the current findings will help researchers better prepare a VR study and promote the use of VR in various applications.

Visual experience affects context dependency mechanisms in auditory distance estimation

Tonelli, Alessia[1]; Mazzola, Carlo[1,2]; Sciutti, Alessandra[1]; Gori, Monica[1]
[1]Italian Institute of Technology, Italy; [2]University of Genoa, Italy;

Often what we perceive does not precisely match the information we receive from our senses but may be influenced by prior knowledge. An example is the phenomenon of central tendency, whereby estimates of specific values, such as distance, duration, or numerosity, tend to converge towards the average of the absolute values. Nevertheless, this mechanism may be modified in populations where perceptual information is distorted due to the absence of a sensory modality, such as blindness.

To tackle this point, we asked a group of blind people, congenital and late, and controls, to perform an acoustic distance reproduction task, in which the stimulus lengths come from different distributions defining two sets of short and long distances. Participants listened to two consecutively presented sounds separated by one of five distances for each set of stimuli (short and long). Once the second sound is localized, participants reproduced the perceived distance starting from that position.

We found a difference between sighted and blind participants in distance reproduction estimates for short and long distances. While the controls and the late blind group show a clear regression toward the mean, the congenitally blind do not. Moreover, the relative importance of the current sensory signal and priors is different among groups. These results suggest that vision may play a role in constructing priors devoted to the distance estimation of sounds.

Auditory–tactile Simultaneity Perception in Adults Treated for Bilateral Congenital Cataracts

Stanley, Brendan M[1]; Chen, Yi-Chuan[2]; Lewis, Terri L[1,3]; Maurer, Daphne[1,3]; Shore, David I[1]
[1]McMaster University, Canada; [2]Mackay Medical College, Taiwan; [3]The Hospital for Sick Children, Canada;

The ability to perceive simultaneity is fundamental to accurate interpretation of the multisensory world. The temporal simultaneity window determines the probability of whether two signals from different modalities will be combined or segregated; if the signals arrive within this window, simultaneity is likely to be perceived. Recently, our group found that adults treated during infancy for bilateral congenital cataracts, when compared to adults with normal vision, demonstrated a wider temporal window for auditory–visual, but not visual–tactile, simultaneity perception (Chen, Lewis, Shore, & Maurer, 2017, *Current Biology*). This selective deficit to auditory–visual, and sparing of visual–tactile, simultaneity perception prompted an investigation of auditory–tactile perception of simultaneity. Here, we tested 15 adults treated for bilateral congenital cataracts (Mean deprivation = 99 days, SD = 55) and 15 normally sighted adult controls. Participants judged whether a beep and tap were simultaneous or not. The temporal window for auditory–tactile simultaneity perception was normal in patients. In the context of our previous work, we conclude that only auditory–visual stimulation manifests a temporal deficit after early deprivation of patterned visual input. In contrast, visual–tactile and auditory–tactile simultaneity perception may be calibrated properly in such patients after the restoration of normal vision. Although it is possible that auditory–visual interactions are simply unique, it is also possible that the tactile modality supports recovery from the effects of the visual deprivation experienced at birth. Because touch occurs on the body surface, it may be able to recalibrate the temporal relations with other sensory inputs.

Cross-condition comparison of self-reported multi-sensory experience

Powell, Georgie[1]; Sumner, Petroc[1]; Ghaiwal, Abhay[1]; Griffin, Charlotte[1]; Price, Alice[1]
[1]Cardiff University, UK;

Many mental, neurological, and neurodevelopmental conditions are associated with differences in multi-sensory experience (e.g., autism, ADHD, OCD, migraine, PTSD, anorexia, anxiety, dyslexia, synaesthesia). In some conditions, such as autism and migraine, sensory experiences form part of the diagnostic criteria. In others, differences in sensory experience are reported anecdotally and sensory items are found in questionnaires that measure their symptoms or traits (e.g. dizziness questions in anxiety scales). The aim of our study was to compare sensory experiences across different conditions, focusing on cross-modal dimensions (hypo- vs hyper-sensitivity, sensory seeking vs sensory avoidance) and individual sensory modalities (vision, audition, tactition, olfaction, gustation, vestibular, proprioception). Participants (n = 739) completed two common sensory experience questionnaires (Adult Sensory Profile and the Glasgow Sensory Questionnaire) and reported any diagnoses or identification with mental, neurological, and neurodevelopmental conditions. We found that the pattern in cross-modal dimensions was broadly similar across all conditions: there was an increase in experiences related to sensory sensitivity and avoidance, and a reduction in sensory seeking, compared to participants reporting no conditions. However, the magnitude of this pattern varied across conditions. We then used linear regressions to find out which of the conditions significantly predicted sensory dimension scores, while controlling for co-occurring conditions, age, and gender. Only autism and ADHD were uniquely associated with differences in all cross-modal dimensions. Next we explored whether different patterns emerged when sensory experience was examined at the level of individual sensory modalities. Some conditions showed differences in particular sensory modalities (e.g. visual, auditory, olfactory sensitivity dominated in migraine), while others showed more broadband differences across modalities (e.g. anorexia, autism).

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Fluctuation of sensory thresholds over 27 days: An eight subject study in migraine

Ikumi, Nara[1]; Marti-Marca, Angela[1]; Vilà-Balló, Adrià[1]; Cerdà-Company, Xim[1]; Torre-Suñe, Anna[1]; Alpuente, Alicia[1]; Caronna, Edoardo[1]; Pozo-Rosich, Patricia[1]
[1]Vall d'Hebron Research Institute, Spain;

Migraine is characterized by the presence of recurrent headache attacks and accompanying sensory symptoms including a hypersensitivity (decreased tolerance) to light, sound, smell, and light touch. Migraine is comprised of different phases, which include specific symptoms and the presence/absence of headache. Most studies to date have evaluated these hypersensitivities separately and at certain phases only. We hypothesized that sensory aversion thresholds would be modulated by headache intensity and migraine phase. During a period of 27 days, we quantified aversion thresholds to light, sound, smell (smoked, lavender, and vanilla), and light touch in 6 migraine patients and 2 non-headache controls. Subjects were asked to judge the aversion of each stimulus through a 2AFC (unpleasant vs. not unpleasant) using an adaptive procedure, or by using a rating scale from 0 (not at all unpleasant) to 10 (extremely unpleasant). To test sensory aversion thresholds, linear mixed-effects models were performed. We replicated previous studies showing a general hypersensitivity to light ($p=0.0262$) and sound ($p=0.0474$) in migraine. Interestingly, the hypersensitivity to light decreased over days in the study more quickly in controls than in migraine ($p=0.0055$). We found that aversion to light ($p.adj<0.0001$), sound ($p.adj<0.0001$), smell (smoked; $p.adj=0.0005$, vanilla; $p.adj<0.0001$, lavender; $p.adj=0.0008$), and light touch ($p.adj<0.0001$) increased with headache intensity in migraine. These results support previous cross-sectional studies showing that the presence of headache can modulate sensory aversion thresholds in migraine. However, only aversion to vanilla odour was clearly modulated along the migraine phase cycle ($p.adj=0.0002$). Our study sheds light into the processes which drive daily fluctuations of sensory perception in migraine. These processes could be relevant for understanding the basic mechanisms underlying sensory perception.

How blurry are echoes? Quantifying the spatial resolution of echoic object perception

Teng, Santani[1]; Ezeana, Michael[2]; Puri, Amrita[2]
[1]Smith-Kettlewell Eye Research Institute, USA; [2]University of Central Arkansas, USA;

Recent research has explored the use of active echolocation by blind individuals, who, by generating mouth-clicks, elicit echoes and use them to perceive and interact with their surroundings. In prior work we showed that expert practitioners can distinguish the positions of objects separated by as little as ~1.5°, the approximate threshold of visual letter recognition at 35° retinal eccentricity. They can also echolocate household-sized objects, then distinguish them haptically from a distractor with significantly above-chance accuracy (~60%). Here we investigated whether the spatial resolution of crossmodal echo-haptic object discrimination is similar to that measured for localization. We found that blindfolded sighted participants tested on the same crossmodal match-to-sample design performed similarly, but with greater inter-individual variability. Performance was similar for both common household objects and novel (Lego) objects of arbitrary shape. This suggests that some coarse object information a) is available to both expert blind and novice sighted echolocators, b) transfers from auditory to haptic modalities, c) is not dependent on prior object familiarity, and d) may require a larger angular size than was subtended by our test objects. Thus, we repeated the match-to-sample experiments using stimuli enlarged by 50% along each dimension. Preliminary results do not show improved performance with larger object size; feedback after each trial in future sessions may improve accuracy. Next, we aimed to directly estimate the equivalent visual resolution of echoic object perception. In a pilot experiment, sighted participants examined target objects visually at 35° eccentricity and, subsequently, identified the target haptically. Performance was ~85%, suggesting that haptic recognition is better informed by visual object information at 35° than by object echoes at the scales we tested. Manipulating visual blur to equate visual and echoic performance will reveal more precisely the spatial resolution of echo-based object perception.

Reading abilities in Deaf: Role of Fovea and Parafovea

Kamble, Veena[1]; Scaltritti, Michele[2]; Crollen, Virginie[1]
[1]Université Catholique de Louvain, Belgium; [2]Università degli Studi di Trento, Italy;

Reading is a complex process that involves visual, phonological, and higher-level semantic processing. Reading difficulty can therefore emerge from impairments at any stage of this circuitry. At the visual level, reading involves the processing of fixated words in foveal vision. While attention to parafoveal information may facilitate foveal word recognition, too much attention to parafoveal region may in contrast hinder identification of the foveal word. There is evidence that deaf individuals present enhanced attention allocation to the periphery, relative to hearing individuals, in low-level visual perception tasks. However, studies examining the impact of this redistribution of attention on the deaf reading skills are still scarce. The present study therefore aims to explore how deaf and hearing adult readers identify letters and words in foveal and parafoveal regions. Word identification was measured by presenting displays of three three-letter words, one on fixation and the others to the left and right of the central word. Accuracy in identifying the component letters of these words when presented at the same location in a context of three three-letter nonword sequences was also measured. Preliminary results showed similar performance by both populations. In the word identification task, accuracy was highest for central targets, followed by words presented in the right hemifield. For letters, accuracy was greatest for the three central letters and for the external ones, i.e., first and last letter of the complete sequence. These results provide evidence for an extended W-shaped serial position function for letter-in-string identification across both populations. Implications of this serial position function, an important factor underlying skilled reading, are discussed with reference to perspectives on visual span in deaf readers.

The neural correlates of canonical versus non-canonical finger-number configurations in deaf, hearing signer and hearing control adults

Buyle, Margot[1]; Lochy, Aliette[1,2]; Vencato, Valentina[1]; Crollen, Virginie[1]
[1]Université Catholique de Louvain, Belgium; [2]University of Luxembourg, Luxembourg;

Several studies suggest that deaf individuals tend to be slower and less accurate in numerical processing compared to their hearing counterparts, especially when processing numbers from symbolic codes. The close intertwining between fingers and numbers has already been demonstrated. The aim of this study was to examine the impact of deafness on the neural correlates underlying the representations of canonical finger-number configurations. A Fast Periodic Visual Stimulation EEG paradigm was used to examine this question in three groups of 21 adults (deaf, hearing signers, controls). One category of stimuli (canonical finger-number configurations) was inserted periodically in streams of another category (non-canonical finger-number configurations) presented at a fast rate. Comparing finger-montring, corresponding to signed numbers, versus finger-counting configurations indicated whether detection of these configurations varies according to a symbolic versus iconic distinction. Results suggest that finger-montring configurations are symbolic for deaf and hearing signers, while finger-counting configurations are iconic for all groups.

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Visual Field Dependence of Crossmodal Interactions in Those with Low Vision

Tanguay Jr., Armand R.[1,2]; Stiles, Noelle R. B.[2,3]; Ganguly, Ishani[2]; Shimojo, Shinsuke[2]
[1]University of Southern California, USA; [2]California Institute of Technology, USA; [3]University of Southern California, USA;

Crossmodal incursion associated with partial vision loss may affect auditory-visual processing in those with low vision as compared with the normally sighted. In particular, crossmodal plasticity during and following vision loss modifies auditory-visual connections, potentially causing the integration of crossmodal information to differ across visual field locations. A visual flash detection task and a double flash task were performed with 24 stimulus locations, eight each at 5, 10, and 15 degrees from fixation. The visual flash detection task tested sensitivity to the visual flashes used in the double flash task (5 flash present trials, and 1 flash absent trial in each location). The double flash task consisted of 10 trials in each visual flash detection location. The patient responses were spatially segregated based on the visual flash detection task, enabling the evaluation of regions with visual perception surrounded by vision loss. Patients 1 and 2 have monocular impairment due to impact trauma and optic nerve disease, respectively (eyes tested separately). Nine naive sighted participants were also tested as controls (with both eyes open). The eye with vision loss exhibited significantly stronger double flash perception relative to the eye with normal visual perception (Patient 1 only, locations with 5/5 flash detections only). Also, the eyes with vision loss in both patients exhibited significantly stronger double flash perception than those of sighted controls (only locations with 5/5 flash detections were included). The stronger double flash perception observed in the eye with low vision as compared with the control eye could be due to diminished visual responses, ocular dominance differences, or crossmodal interactions early in the visual pathway (prior to merging of the binocular inputs, for example in LGN). This pilot data is suggestive of the potential reweighting of audition and vision, and the spatial redistribution of crossmodality, as visual perception is lost.

Neural processing underlying spoken and signed language learning: an fMRI study

Alotaibi, Sahal[1,2]; Meyer, Georg[1]; Wuerger, Sophie[1]
[1]University of Liverpool, United Kingdom; [2]University of Taif, Kingdom of Saudi Arabia;

It is conventionally thought that there is a high degree of similarity in the neural processing underlying signed and spoken languages. Recent data, however, has shown that the brain networks underlying language processing are more complex than initially thought. Here we directly compare the neural processing underlying spoken and sign language learning. In study 1, functional magnetic resonance imaging (fMRI) brain scans were taken from 20 English-speaking volunteers before and after attending a spoken language-training course, learning phonetically minimal distinctions in Arabic that are allophones in the participants' first language, English. The same paradigm was applied in a second study for another group of 26 English-speaking volunteers who were taught British Sign Language (BSL). Again, minimal contrasts between sign language gestures were learnt. Behavioural results for both studies show performance improvement in all variables, including a phonetic discrimination task, and a pronunciation task for spoken language, and a gesture discrimination task and signing task for the sign language group. fMRI results for the spoken language study show significant brain activity increases in the left inferior frontal gyrus (IFG), right cerebellum VIII and the left superior parietal gyrus. Whereas signed language training leads to increased neural activity in left angular gyrus, left middle temporal gyrus, left, posterior cingulate gyrus, left middle frontal gyrus, left hippocampus, right cerebellum VIII and the left inferior frontal gyrus. These results reveal that right cerebellum and left inferior frontal gyrus are the only brain regions that show learning induced activation changes for both tasks.

Causal role of visual and motor cortices in the auditory translation of foreign language vocabulary following multisensory learning

Mathias, Brian[1,2]; Sureth, Leona[2]; Klingebiel, Andrea[2]; Hartwigsen, Gesa[2]; Macedonia, Manuela[3]; Mayer, Katja[4]; von Kriegstein, Katharina[1,2]
[1]Technical University Dresden; [2]Max Planck Institute for Human Cognitive and Brain Sciences; [3]Johannes Kepler University Linz; [4]University of Münster;

According to predictive coding theories of multisensory learning, sensory and motor brain regions that encode multisensory stimuli during learning may support the subsequent recognition of those stimuli, even under unisensory recognition conditions. We tested this prediction in the context of foreign language (L2) learning using the neurodisruptive effects of inhibitory transcranial magnetic stimulation (TMS). In two experiments, participants learned L2 words and their native language translations over 4 consecutive days. Words were learned in two conditions: In one condition, participants viewed and performed gestures as L2 words were auditorily-presented, and in another condition, participants viewed pictures as L2 words were auditorily-presented. Gestures and pictures were congruent with word meanings. Following training, participants underwent effective and sham TMS as they listened to the L2 words that they had learned and translated the words into their native language. In one experiment, we targeted with TMS a visual area associated with the biological motion perception, and in the second experiment, we targeted the motor cortices. Responses in both of these regions were previously found to correlate with the behavioral benefits of performing gestures during L2 vocabulary learning. As hypothesized, TMS slowed the translation of L2 words that had been learned by performing gestures—but not pictures—compared to sham stimulation in both experiments. This result suggests that gesture-based learning altered L2 representations within visual and motor cortices, which then influenced the translation of L2 words. Specialized sensory and motor cortices may therefore play a causal role in remembering the meanings of L2 words following multisensory encoding.

Crossmodal learning of target-context associations

Chen, Siyi; Müller, Hermann; Geyer, Thomas; Shi, Zhuanghua
LMU Munich, Germany;

Contextual cueing is a type of statistical learning of a target location in relation to surrounding context. An important question is how general contextual learning operates across sensory modalities? Does multisensory context learning enhance visual search over and above unisensory learning alone? We addressed this by having participants perform a search task under both a unimodal visual and a visuotactile sessions. Search arrays consisted of one Gabor target that differed from three homogeneous distractors in orientation; participants had to discriminate the target's orientation. In the multisensory session, additional tactile stimuli were delivered to fingers that were co-located with the visual items in half the trials (multisensory redundant signals), while in the other half only the visual array was presented, same as those in the visual session. In both sessions, the visual target was embedded in a repeated spatial context in half of the trials; in the other half, the contextual arrangements were random (non-repeated). Repeated contexts differed between the uni- and multisensory sessions. The results revealed response times (RTs) to become faster, within each session, to targets in repeated vs. non-repeated arrays, evidencing the contextual cueing. This effect was enhanced in the multisensory session – importantly even on trials on which the visual arrays were presented without concurrent tactile stimulation – driven by both a greater number of acquired contexts and a larger cueing effect per learnt context. RT modeling showed that contextual cueing increased the rate at which task-relevant information was accumulated, as well as decreasing the amount of evidence required for a response decision – consistent with acquired context memories facilitating both attentional guidance and response selection. Multisensory learning enhanced particularly the guidance component, expediting target detection even when the context memories were triggered by visual stimuli alone.

Tuesday Morning Talks

Tuesday Talks

8:30am - 9:45am

Room Danube

Multisensory Recalibration

8:30am - 8:45am

Adaptation to hand-tapping directly affects sensory encoding of numerosity and duration of visual stimuli

Burr, David
University of Florence, Italy;

Like most perceptual attributes, perceived numerosity and duration are highly susceptible to adaptation. We have previously demonstrated cross-modal and cross-format adaptation of numerosity: adaptation to auditory sequences affects perceived numerosity of visual sequences, and *vice versa*; and adaptation to both auditory and visual sequences affects the perceived numerosity of visual spatial arrays. Furthermore, adaptation to unseen hand-tapping affects perception of both sequential and simultaneous numerosity. Here we show that motor adaptation also affects the perception of duration, and that the adaptation acts on sensory encoding, not perceptual decisions. Participants tapped in mid-air for a few seconds, either slowly or quickly, then judged (in separate sessions) either the relative duration of two drifting gratings or the numerosity of two dot-clouds; one stimulus was spatially coincident with the tapped region and the other in the opposite field. Fast tapping decreased apparent duration and apparent numerosity within the tapping region, while slow tapping increased it. The effect was spatially specific in external (not body-centered) coordinates, occurring within a 10° region centered on the tapping hand. However, motor adaptation did not affect the perception of visual speed, a lower-level visual property, suggesting that the interactions were at a high level of processing. Further experiments with confidence and reaction-time measures showed that adaptation acts directly on the sensory representation of numerosity, rather than the decisional processes. These results reinforce studies suggesting that visual time perception is coupled with action, and point to the existence of multiple local visuo-motor clocks. That numerosity and duration are affected in similar ways suggests common mechanisms for number and time.

8:45am - 9:00am

Audiovisual spatial integration and recalibration after sight restoration in humans

Bruns, Patrick[1]; Li, L.[1,2]; Guerreiro, M.[1,3]; Shareef, I.[4]; Rajendran, S.[1,4]; Pitchaimuthu, K.[1]; Kekunnaya, R.[4]; Röder, B.[1]
[1]Universität Hamburg, Germany; [2]Western University, Canada; [3]Universität Oldenburg, Germany; [4]LV Prasad Eye Institute, India;

When auditory and visual stimuli are presented with a spatial discrepancy, the auditory stimulus is typically mislocalized toward the visual location (ventriloquism effect), and subsequent auditory localization is recalibrated to correct for the crossmodal mismatch (ventriloquism aftereffect). Both immediate aftereffects following a single audiovisual exposure and cumulative aftereffects following prolonged exposure to a consistent audiovisual discrepancy have been observed. Yet it is unknown to which degree the way we crossmodally recalibrate depends on early sensory experience. Here we tested the ventriloquism effect and aftereffects in individuals who had been born blind due to dense bilateral congenital cataracts (CC group), as compared to normally sighted control participants (SC group) and individuals with a history of developmental (later onset) cataracts (DC group). To measure the ventriloquism effect and the immediate aftereffect, participants were asked to localize audiovisual stimuli with varying degrees of spatial discrepancy that were intermixed with unimodal auditory and visual stimuli. In a second block, audiovisual stimuli had a constant spatial discrepancy of 10 degrees to measure cumulative aftereffects. Results revealed that CC individuals exhibited both typical audiovisual integration (ventriloquism effect) and recalibration (immediate and cumulative aftereffects). However, despite normal crossmodal recalibration of auditory localization, CC individuals showed an additional cumulative recalibration effect on their unimodal visual localization responses which was not seen in other visually impaired individuals (DC) or normally sighted controls. Thus, although vision was capable of recalibrating auditory spatial perception despite the lack of visual input during early development, CC individuals also relied on auditory input to recalibrate visual spatial maps. This suggests that typical and atypical crossmodal mechanisms coexisted in CC individuals and were defined during a sensitive period in development.

9:00am - 9:15am

System identification reveals multiple interacting states responsible for visuomotor adaptation

Balestrucci, Priscilla; Ernst, Marc O.
Universität Ulm, Germany;

Sensorimotor adaptation allows for the flexible control of movements over time in order to maintain adequate action performance despite changes in the environment or our body. The adaptation response to a perceived perturbation is not instantaneous, and the adaptation rate changes according to different factors, e.g. the reliability of error measurement or the rate of change of environmental statistics. This characteristic is in accordance with the Bayesian theory of motor control and is often modeled with a Kalman filter. Yet some of the algorithm's predictions are not confirmed by empirical data, possibly due to having a single free parameter, which may lead the algorithm to becoming too abstract to predict the behavior implemented by the complex physical plant responsible for adaptation. Here, we propose that sensorimotor adaptation can instead be modeled as a system with multiple interacting states, each one described as a Kalman filter. We tested our hypothesis by first measuring motor error in a series of rapid reaching tasks in which we introduced different conditions of feedback uncertainty and systematic perturbations. We then applied system identification techniques to the resulting adaptation response to evaluate which system architecture would better fit our data. We considered three possible architectures: a single Kalman filter, two filters in series, or two filters in parallel. We found that the last structure consistently provided a better fit compared to the other two. On further analysis, we found that the two filters in parallel differed consistently in their adaptation rate, and that they both decreased under higher uncertainty. Moreover, the weight assigned to the faster component was not constant, being highest in the less uncertain condition. We propose that the identified system architecture may provide a more concrete representation for how perceived error is assigned to different components of the physical plant.

9:15am - 9:30am

Judgments of agency and simultaneity following sensorimotor temporal recalibration

Arikan, Belkis Ezgi; Fiehler, Katja
Justus Liebig University Giessen, Germany;

The perception of time between our actions and their sensory feedback is usually continuous, although the sensorimotor system is subjected to various delays: for example, in a multiplayer online video game, the actions of players in the virtual environment can be delayed due to internet connection lag. The sensorimotor system has to deal with such systematic delays by recalibrating the timing between actions and their feedback, as long as causality is maintained (i.e., feedback cannot lead the action). Adaptation can also transfer to another sense; that is, recalibration between actions and visual feedback can be transferred to auditory feedback, indicating a central mechanism that adjusts the timing of action-feedback events. But do we infer agency for the auditory feedback as well? Here, we investigated the existence of cross-modal transfer of agency and simultaneity judgments in a sensorimotor recalibration task. In an adaptation phase, participants executed button presses leading to an immediate or a delayed (150ms) occurrence of a Gabor patch. In a subsequent test phase, they were asked to make simultaneity or agency judgments for actions and feedback (Gabor patch or brief beep) with variable stimulus-onset asynchronies (SOAs) in which the order of actions and feedback was reversed. Linear mixed effects analyses on the preliminary data (N = 30) revealed adaptation for simultaneity judgments for actions and feedback as well as transfer of adaptation from vision to audition when feedback followed the action. Action-feedback order also determined adaptation for agency judgments; however, there was no transfer from vision to audition. Our results indicate a dissociation between agency and simultaneity judgments for temporally contiguous events, in that cross-modal transfer of adaptation can exist without the perception of being in control.

9:30am - 9:45am

The importance of causal-inference for audiovisual spatial recalibration

Landy, Michael S.[1]; Hong, Fangfang[1]; Badde, Stephanie[2]
[1]New York University; [2]Tufts University;

When we encounter misaligned cues from two sensory modalities, the brain must infer which cue is faulty and recalibrate the corresponding sense. We examined whether and how the brain uses cue reliability to identify the miscalibrated sense by measuring the audiovisual ventriloquism aftereffect for stimuli of varying reliability. Visual spatial reliability was smaller, comparable to and greater than that of auditory stimuli. To adjust for modality-specific biases, visual stimulus locations were chosen based on perceived alignment with auditory stimulus locations for each participant. During audiovisual recalibration, participants were presented with bimodal stimuli with a fixed perceptual spatial discrepancy; they localized one modality, cued after stimulus presentation so that both modalities were attended. Unimodal auditory and visual localization were measured before and after the recalibration phase. We compared participants' behavior to the predictions of three models of recalibration: (1) Reliability-based: each modality is recalibrated based on its relative reliability—less reliable cues are recalibrated more; (2) Fixed-ratio: the degree of recalibration for each modality is fixed; (3) Causal-inference: recalibration is directly determined by the discrepancy between a cue and its final estimate, which in turn depends on the reliability of both cues, and an inference about how likely the two cues derive from a common source. Vision was hardly recalibrated by audition. Auditory recalibration by vision changed idiosyncratically as visual reliability decreased: the extent of auditory recalibration either decreased monotonically, first increased and then decreased, or increased monotonically. The latter two patterns cannot be explained by either the reliability-based or fixed-ratio models. Only the causal-inference model of recalibration captures the idiosyncratic influences of cue reliability on recalibration. We conclude that cue reliability, causal inference, and modality-specific biases guide cross-modal recalibration indirectly by determining the perception of audiovisual stimuli.

Tuesday Morning Talks

Tuesday Talks

10:15am - 11:15am

Room Danube

Atypical/Deprivation

10:15am - 10:30am

'Color' Conveyed to the Blind as Timbre Through Sensory Substitution Activates Areas Correlated With Color

Maimon, Amber[1]; Yizhar, Or[1,2]; Amedi, Amir[1]
[1]Reichman University, Israel; [3]Hebrew University of Jerusalem, Israel;

Color and sound have been intimately linked since antiquity. In the classical period, Aristotle viewed colors as analogous to sounds, with favorable colors resembling beautiful harmonies. While perceptual synergies thrived in philosophy and art, research into sensory perception in the brain adhered to a strict separation between the senses, with color being restricted to the visual domain and sound to the auditory. Yet, these views have been shifting in recent years, with research beginning to shed light on the multisensory nature of the brain and its task-based, rather than sensory-based, manners of processing. It is now apparent that the clear-cut individuation of the senses is misguided, and the hegemony of vision is contingent on circumstances in interplay with the other senses. One such circumstance that tilts the balance between the senses is blindness. Blindness, early and congenital in particular, illustrates the development and functioning of the brain in the absolute absence of visual experience. The research of our lab (and others) has shown that the blind can utilize visual areas of the brain for processing information conveyed through alternative sensory modalities. Color presents a unique aspect of visual experience as it is commonly considered to be entirely foreign to the blind. Taking this line of inquiry to the extreme, this study employed fMRI to explore the processing of color in the blind as conveyed using a visual to auditory SSD, the EyeMusic, which codes for a color dimension as represented by different timbres. Peak color active voxels were identified around areas correlated with functional specialization for color in the sighted. As such, we suggest that the area activated is correlated specifically with the object recognition and feature processing tasks often associated with and attributed to color, irrespective of the sensory modality through which they are provided (visual or other).

10:30am - 10:45am

Decoding natural sounds in early "visual" cortex of congenitally blind individuals

Vetter, Petra[1]; Bola, Łukasz[2]; Reich, Lior[3]; Bennett, Matthew[4]; Muckli, Lars[5]; Amedi, Amir[6]
[1]University of Fribourg, Switzerland; [2]Polish Academy of Sciences, Poland; [3]Hebrew University Jerusalem, Israel; [4]UC Louvain, Belgium; [5]University of Glasgow, UK; [6]Reichman University, Israel;

Complex natural sounds, such as bird singing, people talking or traffic noise, induce decodable fMRI activation patterns in early visual cortex of sighted blindfolded participants (Vetter, Smith & Muckli, 2014, Current Biology). That is, early visual cortex receives non-visual and potentially predictive information from audition. However, it is unclear whether the transfer of auditory information to early visual areas is an epiphenomenon of visual imagery or, alternatively, whether it is driven by mechanisms independent from visual experience. We acquired fMRI activity from 8 congenitally blind participants listening to different natural sounds, and derived boundaries of early visual areas V1, V2, and V3 by overlaying probabilistic retinotopic maps from sighted participants onto the reconstructed brain surfaces of blind participants. Using multi-variate pattern analysis, we decoded natural sounds in early "visual" areas of congenitally blind individuals who lack visual imagery. Thus, visual imagery is not a prerequisite of auditory feedback to early visual cortex. Furthermore, the spatial pattern of sound decoding accuracy in early visual cortex was remarkably similar in blind and sighted individuals, with an increasing decoding accuracy gradient from foveal to peripheral regions. This suggests that the typical organisation by eccentricity of early visual cortex develops for auditory feedback even in the lifelong absence of vision. The same feedback to early visual cortex might support visual perception in the sighted (Vetter, Smith & Muckli, 2014, Curr Biol) and drive the recruitment of this area for non-visual functions in blind individuals (Amedi et al., 2003, Nat Neurosci; Bedny, 2017, TICS).

10:45am - 11:00am

Predictive coding in autism spectrum disorders: electrophysiological alterations in early auditory predictive processing as potential markers for autistic symptomatology

van Laarhoven, Thijs[1]; Stekelenburg, Jeroen[1]; Eussen, Mart[2]; Vroomen, Jean[1]
[1]Tilburg University, The Netherlands; [2]Yulius Mental Health, Dordrecht, The Netherlands;

Autism spectrum disorder (ASD) is a pervasive neurodevelopmental disorder that has been linked to a range of perceptual processing alterations, including hypo- and hyperresponsiveness to auditory stimulation. A recently proposed theory that attempts to account for these symptoms suggests that autistic individuals have a decreased ability to anticipate upcoming sensory stimulation. Here, we tested this hypothesis with a series of event-related potential (ERP) studies in which we compared the neural correlates of motor-auditory prediction (N1 attenuation), visual-auditory prediction error (omission N1) and deviancy detection (MMN) of auditory, visual and audiovisual speech between individuals with ASD and age-matched individuals with typical development. The results of our first ERP study showed that, unlike in age-matched participants with typical development, self-initiation of tones through a button press did not attenuate the auditory N1 in autistic individuals, indicating that the ability to anticipate the auditory sensory consequences of self-initiated motor actions might be decreased in ASD. The results of our second study showed that unexpected omissions of a sound of which the timing and content could be predicted by preceding visual anticipatory motion elicited an increased early auditory omission response (oN1) in the ASD group, indicating that violations of the prediction model may produce larger prediction errors in individuals with ASD when compared to their neurotypical peers. Finally, our third study showed that deviancy detection of auditory speech is reduced in autistic individuals, while deviancy detection of visual speech and incongruent audiovisual speech seems to be intact. Taken together, our findings suggest that individuals with ASD may indeed experience difficulties in anticipating upcoming auditory stimulation. Importantly, these difficulties might be due to domain-specific alterations, rather than general impairments in predictive coding. This notion provides potential avenues for future research on electrophysiological markers for autistic symptomatology.

11:00am - 11:15am

Crossmodal Correspondences in Argus II Retinal Prosthesis Patients: Leveraging Auditory-Visual Interactions to Enhance Prosthesis Outcomes

Stiles, Noelle[1,2]; Patel, Vivek[1]; Weiland, James[2]
[1]University of Southern California, USA; [2]University of Michigan, USA;

Crossmodal correspondences map stimuli across the senses (such as between audition and vision), thereby aiding sensory binding and perceptual accuracy. At present it is yet unclear whether these correspondences are changed by prolonged periods of visual deprivation following normal sensory development. Blindness is known to remodel visual cortex to process tactile and auditory sensory information, as well as to alter pathways among the sensory regions. It is conceivable that this reorganization during vision loss may alter crossmodal correspondences between vision and audition, even following visual restoration. To address these questions, we studied crossmodal correspondences in Retinitis Pigmentosa patients with visual restoration by means of Argus II retinal prostheses. Argus II patients have an implanted electrode array that is proximity coupled to the retinal surface. This microelectrode array stimulates still-viable retinal ganglion cells with a video stream from a head-mounted camera. We found that Argus II patients (N = 10) had significant crossmodal mappings equivalent to those of age-matched sighted controls (N = 10) between auditory location and visual location, and between auditory pitch and visual elevation. Furthermore, Argus II patients (N = 6) were able to use crossmodal correspondences to locate a visual target more quickly with auditory cueing than without cueing. Overall, restored artificial vision was shown to interact with audition via crossmodal correspondences, which implies that reorganization during blindness did not prevent the maintenance or relearning of crossmodal mappings. Our results also indicate that a natural sense (audition), can be crossmodally mapped with an artificial sense from a visual prosthesis. In addition, cueing based on crossmodal correspondences was found to improve visual search with a retinal prosthesis. This potentially represents a first step toward leveraging crossmodal interactions for improved patient visual function even with ultra-low-resolution artificial vision.

Tuesday Morning Posters

Tuesday Morning Posters

11:15am - 12:15pm

The macaque posterior cingulate gyrus: a multisensory structure

VITTEK, Anne-Laure[1]; JUAN, Cécile[1]; GAILLARD, Corentin[2]; MERCIER, Manuel[3]; NOWAK, Lionel G.[1]; GIRARD, Pascal[1]; BEN HAMED, Suliann[2]; CAPPE, Céline[1]

[1]Centre de Recherche Cerveau et Cognition, CNRS UMR 5549, Université Toulouse III Paul Sabatier, Toulouse, France; [2]Institut des Sciences Cognitives Marc Jeannerod, CNRS UMR 5229, Université Claude Bernard Lyon I, 69675, Bron, France; [3]Aix Marseille Univ, INSERM, INS UMR1106, Institut de Neurosciences des Systèmes, Marseille, France;

Many cerebral regions are known to be involved in multisensory integration. Even if the posterior cingulate gyrus (PCG) is connected to multisensory regions, very little is known about auditory and audiovisual processing in this area. The PCG is responsive to visual stimulations. To study multisensory integration mechanisms in this area, we recorded single-units and local field potentials (LFP) in response to auditory, visual and audiovisual stimulation in two awake macaque monkeys during a fixation task. The monkeys had to maintain fixation on a central point of a screen during the presentation of a visual stimulus, an auditory stimulus or both. Single-units (n = 196) revealed unisensory (auditory, visual) and multisensory (audiovisual) outputs in this area. Audiovisual neurons represented a little more than half of the neurons. Multisensory integration was mostly subadditive and suppressive. LFPs (n = 242) were analyzed in the time domain and in four frequency bands. Our results confirm PCG activity in response to visual stimulation and reveal that PCG also responds to auditory stimulation. They also show that this area is involved in multisensory processing: we observed audiovisual evoked potentials, statistically different from the auditory and the visual evoked potentials. The frequency analysis showed a distinction between low and high frequencies. The low frequencies (4.5-8.5 Hz and 8.5-20 Hz) were strongly multisensory (respectively 72% and 84% of the sessions), whereas high frequencies, divided in 35-60 Hz and 60-120 Hz, were distributed between unisensory visual and multisensory responses. Multi-units (n = 107) and LFP responses were different (except for the 60-120 Hz frequency band): the distribution of all responses types (auditory, visual, multisensory and no response) was not the same. Notably, they were more multisensory responses in the LFP than in the multi-units. Altogether, our study shows that the posterior cingulate is involved in multisensory integration.

A temporally correlated visual signal improves the neural representation of an auditory object

Nidiffer, Aaron R[1]; Lalor, Edmund C[1,2]

[1]University of Rochester, United States of America; [2]Trinity College Dublin, Ireland;

The human brain is capable of processing complex acoustic environments, binding features of auditory signals into meaningful units called objects while also segregating objects from background noise. One cue that aids in this process is common temporal dynamics shared between features. Evidenced by behavioral, fMRI, and EEG data, humans can form objects from acoustic signals, called stochastic figure-ground (SFG) stimuli, based solely on temporally coherent frequency changes within that signal, despite complete spectrotemporal overlap between the object and a background. It is rare that events in the environment produce energy in a single sensory modality, and so we asked how a visual stimulus might affect object formation when observing these SFG stimuli. Specifically, we sought to determine how the temporal correlation between an auditory object and a visual signal affected object formation. We modified previously used SFG stimuli so that the timing of frequency changes was irregular. While recording high-density EEG, we presented these stimuli along with one of two visual streams: one with flashes timed to match frequency changes in the auditory object and one with independent flashes with similar temporal statistics. Via forward encoding models (the Temporal Response Function), we found a neural representation of the object in EEG in fronto-central electrodes typical of auditory signals. When the visual signal matched the object, this representation was enhanced in these electrodes and emerged in parietal electrodes. Preliminary results from a second experiment suggest that alpha power tracked the formation of the auditory object and that this tracking was faster when the visual signal matched the auditory object. Meanwhile, power in the beta frequency band tracked the correlation between the object and visual stimulus. Taken with previous findings, these results support a complex relationship between multisensory integration, attention, and binding that is susceptible to consistency across sensory features.

Decoding acoustic and visual features of continuous speech from EEG in children and adults.

Fantoni, Marta[1]; Federici, Alessandra[1]; Campogonara, Ivan[2]; Ricciardi, Emiliano[1]; Martinelli, Alice[1]; Nava, Elena[3]; Bednaya, Evgenia[1]; Bottari, Davide[1]

[1]IMT Scuola Alti Studi Lucca, Italy; [2]New York University Abu Dhabi, Abu Dhabi, United Arab Emirates; [3]University of Milan Bicocca, Italy;

Neural entrainment refers to the temporal alignment of neural activity with the regularities of an occurring stimulus. While few studies investigated audio-visual speech processing in adults, how neural entrainment unfolds in children is still unclear. Here, we quantified how well acoustic and visual features of speech can be decoded from children and adult neural activity. We recorded the EEG while participants (17 children, mean-age: 8y, range: 5-12; 16 adults, mean-age: 26y, range: 24-31) were exposed to continuous audio-video speech. Neural entrainment was measured through backward modeling to reconstruct stimulus features from the neural response. The sound-envelope and the area subtending lip-movements were used as acoustic and visual regressors. First, we assessed the entrainment to sound envelope and lip-movements by comparing each of them against a null-distribution. Then, reconstructed signals of sound-envelope and lip-movements were directly contrasted to compare their outcomes. Analyses were performed on the time-lags between 0-600 ms, representing the delay of neural activity associated with the processing of sound-envelope or lip-movements. In children, successful reconstruction performance was obtained for both reconstructed signals. For sound envelope reconstruction performance consistently differed from the null-distribution at time-lags up to 420 ms, whereas for lips movements up to 450 ms. The reconstruction of sound- envelope exceeded the reconstruction of lips movements between 5 and 210 ms. In adults both sound envelope and lips-movements differed from null-distribution up to 495 ms. The comparison between the acoustic and visual regressors showed a greater reconstruction performance of the sound envelope between 5-150 ms. Our results revealed that backward modeling can be successfully applied to sound envelope and lip-movements to measure speech entrainment in both children and adults. Regardless of the age, reconstruction performance was greater for sound envelope than lip-movements at early time-lags, that is, in the first phases of stimulus processing.

Physical properties of eye movement-related eardrum oscillations (EMREOs) in the rhesus monkey

Schlebusch, Stephanie N.[1]; Kaylie, David M.[1]; King, Cynthia D.[1]; Shera, Christopher A.[2]; Groh, Jennifer M.[1]

[1]Duke University; [2]University of Southern California;

The auditory, visual, and oculomotor systems work together to ensure surrounding stimuli are perceived correctly. We have recently reported an oscillation of the eardrum that is time-locked to the onset or offset of an eye movement in the absence of sounds or visual stimuli. These eye movement-related eardrum oscillations (EMREOs) suggests that interactions between auditory, visual, and oculomotor systems may begin as early as the ear itself. Much is still unknown about this phenomenon. Open questions include: 1) Which motor systems of the inner and middle ear contribute to this eardrum oscillation- potential components include the stapedius muscle, tensor tympani muscle, and/or outer hair cells, 2) What are the neural circuits in the brain that drive this oscillation all the way to ear? 3) What are the cognitive or perceptual effects of this oscillation, especially with respect to sound localization? To study the anatomical and neural circuits in controlled experiments, we use the rhesus monkey as an animal model in which we can perform controlled invasive surgical and pharmacological manipulations that cannot be performed in humans. The rhesus monkey is able to perform saccadic eye movements on similar time scales to human participants and we are able to record ear canal changes in the same manner as with human participants. Rhesus monkeys have a highly-reproducible oscillation in both ears, comparable to humans, including alternating phase of the oscillation between the ears and separable horizontal and vertical components related to the horizontal and vertical components of the simultaneous eye movement. Finally, rhesus monkeys allow for a single, specific surgical or pharmacological intervention after baseline data collection, data collection almost immediately after the procedure, and data collection on the order of thousands of trials to reach significance in each subject.

Prior Exposure Enhances Cortical Entrainment to Unheard Speech during Silent Lip-reading

Cao, Zhewei "Cody"[1]; O'Sullivan, Aisling E.[4,5]; Szymula, Lauren A.[2,3]; Nidiffer, Aaron R.[2,3]; Lalor, Edmund C.[2,3,4,5]

[1]Department of Brain and Cognitive Sciences; [2]Del Monte Institute of Neuroscience; [3]University of Rochester, USA; [4]Trinity Center for Bioengineering; [5]Trinity College Dublin, Ireland;

Neuroimaging research has demonstrated that observing visual speech in the absence of auditory speech activates primary auditory cortex. However, it remains unclear what this activation precisely reflects. It is well established that, during continuous auditory speech, neural activity in auditory cortex tracks the temporal envelope of the speech signal. Recently, it has been suggested that this process may in fact reflect an internal synthesis of the speech stream rather than the encoding of the envelope per se. In the current study, we look into whether silent lip-reading can elicit a similar “entrainment” to the envelope in the absence of auditory speech. In the current study, we trained subjects to be good lip readers on 5 audiovisual videos of a speaker, and then asked subjects to perform a target word detection task to the silent version of the 5 trained videos, as well as 5 novel silent videos of the same speaker. We tracked both behavioral performance and recorded electroencephalography (EEG) data during testing. Results showed that subjects exhibited higher accuracy in trained videos over novel ones in the target word detection task. Additionally, by reconstructing an estimate of the silent audio speech envelope from the EEG signal, we find that when the speech could be accurately lip-read, the speech envelope can be more accurately reconstructed. With these results, we show supporting evidence that silent lip-reading does in fact dynamically activate auditory cortex in a way that is meaningfully related to the speech stimulus.

Tuesday Morning Posters

Tuesday Morning Posters

11:15am - 12:15pm

Short-term monocular deprivation boosts neural responsiveness to audio-visual events for the undeprived eye

Federici, Alessandra[1]; Bernardi, Giulio[1]; Senna, Irene[2]; Fantoni, Marta[1]; Ernst, Marc[2]; Ricciardi, Emiliano[1]; Bottari, Davide[1]
[1]MoMiLab, IMT School for Advanced Studies Lucca, Lucca, Italy; [2]Ulm University, Ulm, Germany;

A brief period of monocular-deprivation (MD) is known to elicit in adults short-term plasticity of the visual system. Behavioral studies have shown that MD can also affect multisensory perception. Here we investigated causal effects of MD on neural oscillations during visual and audio-visual processing. Twenty young adults (mean age 28.45±2.67 SD) performed monocularly a visual discrimination task before (t0) and after (t1) a phase of MD (150min) while the EEG was recorded. Participants were asked to report the number of perceived flashes while irrelevant beeps could be presented. Neural responses to both visual and audio-visual events were investigated with a series of analyses between power change (t1 minus t0) in Deprived and Undeprived eye, across all electrodes, timepoints [0-0.5s], at low [4-30Hz] and high [30-80Hz] frequency ranges. Separate analyses were conducted on induced and evoked activity, representing non phase-locked and phase-locked oscillations with stimulus onset, respectively. Source estimation was performed to identify involved brain areas. Behaviorally, we estimated visual and audio-visual sensitivity change (t1 minus t0) in each eye. Results showed that induced alpha power [10-16Hz] decreased within the first 150ms of visual processing selectively for the Deprived eye. This effect was localized in the right parieto-occipital area and was associated with decreased visual sensitivity. During audio-visual processing, induced gamma activity [65-75Hz] increased between 100-300ms selectively for the Undeprived eye. This effect emerged at the right intraparietal sulcus and left thalamus. Results revealed distinct neural signatures for visual and audio-visual MD effects. While visual alpha decreased after MD selectively for the Deprived eye, gamma increased for the Undeprived eye during audio-visual processing, indicating upweighted responsiveness to auditory events. Notably, both unisensory and multisensory processing alterations were found selectively for induced neural oscillations, revealing a prominent role of feedback connectivity in short-term plasticity.

The contribution of visual dynamics and articulatory details to audiovisual speech perception in noise

O'Sullivan, Aisling[1]; Nidiffer, Aaron[2]; Lalor, Edmund[1,2]
[1]Trinity College Dublin, Ireland; [2]University of Rochester, USA;

Seeing the face of the speaker you are listening to benefits speech intelligibility - particularly in noisy situations. Behavioral studies have found that listeners predominantly gaze at the lips of the speaker when the acoustics are noisy (Vatikiotis-Bateson et al., 1998). The use of lip information under such conditions is not surprising since the lips convey general dynamic information (which is correlated with the acoustic envelope), as well as detailed articulatory movements which provide complementary information. It remains unknown however, how the mouth dynamics and mouth details (e.g., teeth and tongue) differentially contribute to the improved intelligibility of noisy speech. In particular, it is unclear how this information impacts different hierarchical stages of auditory speech processing in the brain. Here we present an experiment designed to test this by blocking the articulatory information from the lips - while the mouth dynamics and the rest of the facial information remains intact as participants listen to audiovisual (AV) speech in noise (-7 dB). Regarding speech intelligibility, our results show that the behavioral benefits of visual speech depend on access to both visual speech dynamics and articulatory information. Our EEG analyses focuses on relating different speech representations (i.e., envelope, spectrogram, phonemes) to the EEG data in order to index multisensory integration effects at different hierarchical levels of auditory speech processing. Our hypothesis is that multisensory effects at the level of phoneme processing will be markedly reduced for the blurred mouth AV condition due to the removal of articulatory details in comparison with the clear mouth AV condition. However, we expect the multisensory effects at the level of spectral processing to be similar for both clear and blurred mouth AV speech. These results will extend our understanding of the contribution of visual speech features to audiovisual speech perception.

Perceptual cognition during illusory self-motion: vection, cybersickness and top-down control

Taylor, Paul; Obereisenbuchner, Florian; Dowsett, James
LMU Munich, Germany;

When participants observe optic flow – simulating the visual input seen if really moving through the world – they often report the illusory sensation of self-motion, (vection), or feel visually-induced motion (or cyber-) sickness, and posturally sway, as if adjusting their balance. We wanted to know if the effects of optic flow are modulated by top-down control. One reason to think this might be the case is that passengers in a car classically get more travel sick than the driver: the key difference being in how predictable the optic flow is. In our experiment, seated participants could self-initiate optic flow onset with a manual button press, contrasted with passive conditions. Self-initiation inhibited both postural and electrophysiological responses to optic flow. We also found an intriguing correlation between vection and cybersickness [1]. We are currently following up these findings up by exploiting steady state visually evoked potentials (SSVEPs), a robust EEG measure which allows probing the frequency-specific response of the cortex. We found a differential hemispheric lateralisation of the neural response during vection [2], with the future exciting potential of extending this to real, mobile locomotion. These results illuminate how the multisensory systems of the human brain are capable of predicting optic flow when self-initiated, to affect behaviour. It is vital for understanding perceptual cognition to acknowledge the wide-ranging and multisensory effects that optic flow can have on the mind, brain and body.

[1] Obereisenbuchner, F., J. Dowsett, and P.C. Taylor, *S.* Neuroscience, 2021 [2] Dowsett, J., et al., Eur J Neurosci, 2020

Time-to-collision estimates for accelerating vehicles show stronger audiovisual benefits for conventional compared to electric vehicles

Oberfeld, Daniel; Wessels, Marlene; Dimmler, Vanessa
Johannes Gutenberg-Universität Mainz, Germany;

Pedestrians standing at the curb and intending to cross the road while a vehicle is approaching need to accurately judge the time remaining until the vehicle will arrive at their position (time-to-collision, TTC). For accelerating objects (increasing speed), the literature on visual TTC estimation indicates that the acceleration is largely ignored, showing so-called first-order TTC estimations that result in a potentially risky overestimation of the actual TTC. However, we recently found that the sound of vehicles with internal combustion engine (ICEVs), which provides salient auditory information about the acceleration state, significantly improves the TTC estimation for accelerating vehicles, compared to a silent visual-only condition. Here, we investigated whether this audiovisual benefit also applies to accelerating electric vehicles (EVs) with a less salient acoustic signature. In an interactive and highly realistic audiovisual virtual-reality simulation, a vehicle approached the participants, initially at a constant speed, followed by an acceleration phase. The acoustic simulations were based on acoustic recordings of an ICEV and of EVs with active or inactive acoustic vehicle alerting system (AVAS), combined with physical modeling of the sound transmission and spatial rendering via sound field synthesis. The simulated motion and the visual simulation of all vehicle types were identical, only the sound differed. In the visual-only condition, the TTC was increasingly overestimated as the presented TTC increased, showing the expected first-order pattern. In the audiovisual condition, a similar pattern was observed for the EV without AVAS, and in a slightly reduced form also for the EV with AVAS. In contrast, for the ICEV, the first-order pattern in the TTC estimates was largely removed, the estimates were close to the veridical values. Thus, the sound of an accelerating ICEV provides a significant audiovisual benefit in TTC estimation, which is significantly reduced for electric vehicles. Implications for traffic safety are discussed.

Escape from Dizzyland: a web-based clinical rehabilitation program for people with Persistent Postural Perceptual Dizziness (PPPD)

Goodwin, Nathan Joshua[1]; Sumner, Petroc[1]; Loizides, Fernando[1]; Derry-Sumner, Hannah[2]; Powell, Georgina[1]
[1]Cardiff University, UK; [2]University Hospital of Wales, Cardiff, UK;

Persistent Postural Perceptual Dizziness (PPPD) is a multisensory condition whereby disabling dizziness is triggered by visual movement or complex environments (e.g. supermarkets). Leading theories claim that cue combination for balance is inappropriately weighted, with over-reliance on vision relative to vestibular and proprioception. Treatment involves “optokinetic desensitisation”: to “down-weight” visual information through exposure to triggering visual stimuli while stationary (minimising vestibular signals and creating conflict). However, current treatment involves passively watching dynamic abstract patterns, which is unengaging and leads to high patient attrition. We have built a game for PPPD that: aims to increase engagement and enjoyment; is flexible and allows patients graded control over their visual stimulation as treatment progresses; includes virtually rendered real-life environments to reduce situational anxiety; causes a visual-vestibular conflict by providing visual movement cues to participants whilst they are seated. Stage 1 and 2 piloting (21 participants) has shown that dizziness, nausea, and discomfort symptoms increased as expected as visual flow increased - in theory, a prerequisite for desensitisation. Participants rated the game ‘highly usable’ on the System Usability Scale. Importantly, participants reported that they would play the game if it aided their PPPD rehabilitation, despite it triggering discomfort. The interactive element was highly valued and preferred over traditional approaches of passively watching videos. In the next stage, we will in parallel i) test the rehabilitation efficacy of the game with a randomised-control trial, and ii) aim to understand more about the multisensory triggers and underlying causes of PPPD.

Tuesday Morning Posters

Tuesday Morning Posters

11:15am - 12:15pm

Resampling through touch rather than vision when checking ambiguous stimuli: a new metacognitive bias

Fairhurst, Merle Theresa[1,2]; Travers, Eoin[3]; Hayward, Vincent[4,5]; Deroy, Ophelia[2,5]
[1]Bundeswehr University, Munich, Germany; [2]LMU Munich, Germany; [3]UCL, London, UK; [4]Sorbonne Universités, France; [5]University of London, UK;

To act and adapt our behaviour, we often sample evidence through several senses either in parallel or one after the other: for example, estimating the size of something first through vision and then by manipulating the same object with our hands. Which modality and why we choose to trust the information we get from it, both in everyday scenarios as well as in clinical cases, may depend on the nature of perceptual metacognition. Here, we further investigate a previously observed metacognitive bias for touch for ambiguous stimuli, again employing the vertical horizontal illusion. The inverted t-shape stimuli range from clear cut cases where the relative length of the vertical bar is unambiguous or highly ambiguous cases where the illusion is strongest. Participants first explored the stimuli through vision and touch (bimodal sampling). In two separate blocks, they then either were instructed ("forced resampling") or chose ("free resampling") to resample either through vision or touch (unisensory resampling). In doing so, we validate free resampling as a novel implicit measure of confidence and examine how checking an ambiguous stimulus by either touch or vision is effects perceptual judgments and perceived confidence. We show that for highly ambiguous stimuli, people prefer to check by touch, despite an overall tendency to check again by vision. Specifically, our data show that participants forced to resample through touch rather than vision are more likely to change their minds. Moreover, they are more likely to choose to resample through touch when uncertain, and more likely to change their perceptual decision even when we control for initial uncertainty. This further evidence of a bias for touch will be discussed in terms general theories of metacognition as well as functional differences that may explain why we choose to trust touch over vision in cases of uncertainty.

Visual and tactile signals to contact duration are not integrated, but signals to object properties are: implications for multisensory integration processes and artificial touch stimulation.

Watt, Simon[1]; Krishnan, Anantha[1]; Doppertin, Lea[2]; Seminara, Lucia[3]
[1]Bangor University, UK; [2]Hamburg University of Applied Sciences (HAW Hamburg), Germany; [3]University of Genoa, Italy;

In natural hand movements, tactile sensation provides important signals about when we make contact with objects, and the properties of those objects. Endowing devices such as prostheses and remote-manipulation systems with (artificial) tactile signals could in-principle improve their efficacy significantly, but is challenging in practice. Here, we apply a multisensory-integration approach to understanding fundamental aspects of how tactile signals are processed, with the ultimate aim of informing the development of artificial touch stimulation. Because touch and vision provide redundant signals, we might expect multisensory integration to occur, evident as increased precision with both senses compared to with either sense alone. We assessed multisensory integration for judgements of (i) duration of passive fingertip contact of a mechanical probe, and (ii) orientation of a raised ridge (an 'object' property) actively touched with the fingertip. For both we determined discrimination thresholds in tactile-only, visual-only, and multisensory visual-plus-tactile conditions (2-IFC task). We probed the presence of integration by comparing observed and predicted multisensory discrimination performance, with predictions generated using measured single-sense performance, and a statistically-optimal integration model (MLE). We found very limited evidence for visual-tactile integration in judgements of contact duration. However, we found performance consistent with multisensory integration in visual-tactile orientation judgements. We tentatively propose that this difference results from the fact that duration of contact cannot be sensed directly—it is a 'second-order', derived property—whereas there are direct sensory signals to object orientation from vision and touch, allowing integration at (relatively) low level. Visual-tactile integration demonstrates that the brain 'knows' how signals captured by two different sensory systems relate to one another. The presence (or absence) of visual-tactile integration therefore has the potential to probe, at an automatic, unconscious level, whether artificial tactile stimulation provides signals that are comprehensible to the brain. Orientation may be a suitable property for such explorations.

Virtual Tool-use: Do Tool-use Effects Extend to Virtual Reality?

Bell, Joshua D.; Macuga, Kristen L.
Oregon State University, United States of America;

Recently, it has been suggested that movements in virtual environments may leverage different mechanisms than those in real environments, making it essential to validate virtual reality for the study of motor control and related processes, such as tool-use (Harris et al., 2019). A predominant theory of tool-use, termed tool embodiment, posits that tool-use is facilitated by changes to a highly plastic, action-oriented body representation termed the body schema (Martel, Cardinali, Roy, & Farnè, 2016). Following seminal work by Cardinali et al. (2009), changes in reaching kinematics and participants' localization of body landmarks have been taken as an indicators of tool embodiment. To determine whether the use of a virtual environment influences these tool-use effects, the present preregistered study sought to replicate Cardinali et al. (2009)'s original work with several extensions, including the projection of a virtual environment via head-mounted display. Twenty-four participants completed a manual grasping task, as well as a landmark localization task, before and after using a 40cm grabber tool. The grasping task involved lifting and replacing a 3D-printed cube. The landmark localization task required participants to stop an oscillating sphere when it was aligned with the wrist, forearm or elbow. All tasks occurred in a virtual environment, with the hand, tool, and reaching object tracked using a combination of infrared and SteamVR trackers. Kinematic peaks (velocity, acceleration, deceleration) were derived from the outward reaching movements, while localization errors were taken from the landmark task. Bayesian hierarchical analyses heavily favored the null hypothesis, suggesting that tool-use effects did not generalize to a virtual environment. While follow-up experiments are underway to add more resolution to these results, they support the notion that validation studies are crucial when aiming to study sensorimotor processes in virtual environments.

Interacting with multi-material objects: Learning new density cues for grasping

Mehraeen, Sina[1]; Adams, Wendy J.[2]; Ernst, Marc O.[1]
[1]Ulm University, Germany; [2]University of Southampton, United Kingdom;

Our ability to learn and make use of visual and haptic material cues, e.g. for inferring an object's density is not well understood. Previous research has shown that when individuals grasp objects made of a single homogeneous material, they use visual shape cues to aim for the center of mass in order to minimize torque. Here we probe how humans use information from vision and touch to guide grasping, when the target object has non-homogeneous density. Nine cylindrical objects were constructed from varying proportions of PVC and metal piping, such that the center of mass deviated systematically from the geometric center. Participants lifted the objects in pseudo-random order using a pincer grasp. In Experiment 1, participants were visuo-haptically exposed to the two different materials prior to the grasping task; these materials had a natural density ratio: metal was 3 times as dense as PVC. In Experiment 2, observers had no prior exposure to the two materials. In condition 2A, observers lifted the same objects as in Experiment 1. In condition 2B, the objects were visually identical to those in Experiment 1 but the material densities were manipulated such that the PVC was 3 times denser than the metal. To confirm the influence of life long learning, in Experiment 3 we reversed the order of Experiment 2 and investigated the time course during switch back. For initial lifts, observers exploited (i) cues to material density from vision and (ii) information from prior exposure, to guide finger placement away from the geometric center and toward the center of mass. Learning further reduced torque across subsequent lifts. Interestingly, this learning was faster with prior exposure to the materials (Experiment 1). Observers' grasp locations are well explained by an exponential model that combines expectations of material density with visuo-haptic learning to minimize torque.

Auditory Spatial Cueing Improves Visual Target Discrimination Performance in Virtual Reality

Alwashmi, Khaloud[1,2]; Meyer, Georg[1]; Rowe, Fiona[1]; Ward, Ryan[1]
[1]University of Liverpool, United Kingdom; [2]Princess Nourah bint Abdulrahman University, Saudi Arabia;

Introduction and background: In real world settings, humans, perceiving and responding to external events, rely on simultaneous interaction between multiple sensory systems. Spatial and temporal coincidence of multisensory inputs affects both physiological and perceptual responses. Investigating cross-modal learning effects in virtual environments can help in determining how information is integrated across sensory modalities. A key question in this area is how training on specific cue combinations transfers across tasks such as voluntary and involuntary eye movements. Methodology: Twenty healthy participants trained at home on virtual reality (VR) for 30 min daily, five days a week and for four weeks. Performance data (response times (RT), accuracy, and total score) were logged on the VR system during training. In addition, more formal laboratory tests, including voluntary and involuntary eye movement measures, and target detection performance were conducted. Each test was performed with and without audio cues to compare the behavioural learning performance between the two conditions. Results: We quantified search performance using the following metrics: for the VR task, we measured the mean RT and showed a significant increase in the speed to process individual stimuli. We showed that the overall correct rate was over 90%. In addition, we ran formalised tests to measure behavioural performance and eye movement data in a voluntary, an involuntary and a visual search task. The AV voluntary task mean RT decreased significantly when comparing pre to post training sessions (from 0.7s (±0.02) to 0.55s (± 0.01), $p < 0.0001$). The audio-visual (AV) localization learning effect was found transfer to the other two paradigms, when comparing AV to non-audio conditions. Conclusion: Systematic AV training in VR provides noticeable performance gains, with a transfer of learning to the involuntary and visual search conditions. This could usefully translate into rehabilitation sittings.

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Geometry intuitions without vision? A study in blind children and adults

Marlair, Cathy; Pierret, Elisa; Crollen, Virginie
Université Catholique de Louvain, Belgium;

Geometry intuitions seem to be rooted in a non-verbal system that humans possess since early age and share with other animal species. However, the mechanisms underlying the comprehension of basic geometric concepts remain elusive. Some authors have suggested that the starting point of geometry development could be found in the visual perception of specific features in our environment, thus conferring to vision a foundational role in the acquisition of geometric skills. To examine whether vision is mandatory for the development of geometry, a test probing intuitive understanding of basic geometric concepts (e.g., line, points, figures, symmetry) was presented to twelve congenitally blind children and nineteen congenitally blind adults. Our results showed that the blind presented poorer performance as compared to the sighted participants who did the task in the visual modality (i.e., with the eyes open), but they performed equally well as the sighted who did the task in the tactile modality (i.e., with a blindfold). We therefore provide first evidence that geometric abilities are hindered by the lack of vision.

Learning a new class of multisensory associations: high-density electrophysiological mapping of the temporal course of audio-visual object processing

Vercillo, Tiziana[1]; Freedman, Edward G.[2]; Molholm, Sophie[2,3]; Foxe, John J.[2,3]
[1]The Donders Institute for Brain, Netherlands; [2]University of Rochester, USA; [3]Albert Einstein College, New York, USA;

Multisensory objects, frequently encountered in the natural environment, can produce strong associations across a distributed sensory cortical network, leading to perception of a unitary object. Remarkably little is known, however, about cortical processes underlying multisensory object formation and recognition. Here, we investigated the neural processes involved in learning and identification of novel visual-auditory objects, testing a rudimentary, three-stage model of multisensory object-formation and processing. Specifically, we examined whether multisensory electrophysiological responses change over time in terms of their amplitude and the underlying brain network topologies, as the multisensory elements of a newly introduced class of audio-visual associations become more strongly bound into well-known object associations. Thirty adults participated in an incentivized multi-day training protocol in which they learned the novel pairings of multisensory objects (3D shapes paired to complex sounds). High-density event related potentials (ERPs) were recorded to the corresponding unisensory (shapes or sounds only) and multisensory (shapes and sounds) stimuli, before and after the intensive training. We identified three major stages of multisensory processing: 1) an early, multisensory, automatic effect (<100 ms) in occipital and frontal areas, related to detection of simultaneous audiovisual signals and not multisensory learning; 2) an intermediate object-processing stage (70-130 ms) in occipital and centro-parietal areas, sensitive to the learned multisensory associations; and 3) a late multisensory processing stage (>200 ms) that was likely involved in memory consolidation. These results provide support for the hypothesis that there are multiple stages of multisensory object learning and recognition, subserved by an extended network of cortical areas.

Multisensory memory benefits are object-specific

Duarte, Shea Elizabeth[1,2]; Geng, Joy[1,2]
[1]Center for Mind and Brain, University of California, Davis; [2]Department of Psychology, University of California, Davis;

Visual object recognition memory is better for objects encoded alongside their characteristic sounds (e.g., a dog and a bark). Recent research showed that this redundant auditory information specifically benefits recollection-based recognition memory, suggesting that the recognition enhancement is based on improved encoding of specific details of the episodic event rather than improvement to familiarity-based recognition (Duarte et al., 2021). While previous work has focused exclusively on multisensory memory effects on individual objects, recollection-specific effects may also improve memory for additional items present within the visual field at encoding. In the present work, we investigated the impact of a multisensory item on memory for a second visual object at encoding. Participants performed an audiovisual encoding task in which pairs of visual objects were presented with a sound that was congruent with one of the objects or a control white-noise sound. Participants reported whether just one of the objects (indicated by a retroactive cue) would fit in a suitcase (Experiment 1) or whether the two items were related (Experiment 2). For both experiments, they performed a recollection/familiarity recognition task for each individual visual item after encoding. Experiment 1 replicated the finding that congruent audiovisual objects are recollected better than visual items paired with control sounds, and showed that audiovisual items did not improve or hinder memory for the additional visual object present at encoding. Experiment 2 showed that when participants are required to consider the relationship between the two visual items at encoding to further bind them to each other, the memory benefit of audiovisual processing is mitigated, such that recognition memory was not better for audiovisual than control items. These results suggest that multisensory processing supports memory for an audiovisual object over surrounding visual information rather than supporting overall recollection for details from an encoded episodic event.

Spatial action-effect binding depends on type of action-effect transformation

Liesner, Marvin; Kirsch, Wladimir; Pfister, Roland; Kunde, Wilfried
Julius-Maximilians-Universität Würzburg, Germany;

Spatial action-effect binding denotes the mutual attraction between the perceived position of an effector (e.g., one's own hand) and a distal object that is controlled by this effector. Such spatial binding can be construed as an implicit measure of the inclusion of the controlled object into the agent's body representation. In two experiments, we investigated how different transformations of hand movements into movements of a visual object affect spatial action-effect binding. In Experiment 1, we found a significantly lower drift of the proprioceptive position of the hand towards the visual object when hand movements were transformed into inverted cursor movements rather than cursor movements in the same direction while the actual physical distance between hand and object was held constant. Experiment 2 showed that this reduction reflected a complete elimination of spatial binding in the inverted condition. The results will be discussed against the idea that conflicting sensory inputs lead to the suppression of those input channels that are less relevant for the current task. Furthermore, they broaden our understanding of the prerequisites for an experience of ownership over artificial, non-corporeal objects by showing that direct control over how an object moves is not a sufficient condition for a sense of ownership because integration of a remote object and one's body representation can be fully abolished even under conditions of full controllability.

Sounds changing in pitch interact with proprioception when paired with body movement, affecting motor behaviour and bodily feelings

Ley-Flores, Judith[1]; Bevilacqua, Frédéric[2]; Bianchi-Berthouze, Nadia[3]; Tajadura-Jimenez, Ana[1,3]; Deroy, Ophelia[4,5]
[1]Universidad Carlos III de Madrid, Spain; [2]Sorbonne Université, Paris, France; [3]UCL, London, UK; [4]LMU München, Germany; [5]University of London, UK;

The effects of music on bodily movement and feelings, such as when people are dancing or engaged in physical activity, are well-documented—people may move in response to the sound cues, feel powerful, less tired. How sounds and bodily movements relate to create such effects? Here we deconstruct the problem and investigate how different auditory features affect people's body-representation and feelings even when paired with the same movement. We looked more specifically at how bodily movement, proprioceptive awareness (sustained by body schema) and subjective feelings related to the body, one's movement and emotional state, are affected by auditory changes. In three experiments, participants executed a simple arm raise synchronised with changing pitch in simple tones (Experiment 1), rich musical sounds (Experiment 2), and within different frequency ranges (Experiment 3), while we recorded indirect and direct measures on their movement, body representations and feelings. Changes in pitch influenced people's general emotional state as well as the various bodily dimensions investigated—movement, proprioceptive awareness and feelings about one's body and movement. Adding harmonic content amplified the differences between ascending and descending sounds, while shifting the absolute frequency range had a general effect on movement amplitude, bodily feelings and emotional state. These results provide new insights in the role of auditory and musical features in dance and exercise, and have implications for the design of sound-based applications supporting movement expression, physical activity, or rehabilitation.

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Changing tactile amplitude and frequency perception via autosuggestion

Myga, Kasia Anna[1,2,3]; Kühn, Esther[3,1]; Azañón, Elena[1,2]
[1]Otto-Von-Guericke University Magdeburg; [2]Leibniz Institute for Neurobiology, Magdeburg; [3]Center for Behavioral Brain Sciences, Magdeburg, Germany;

Autosuggestion is the instantiation and reiteration of ideas or concepts by oneself aiming to actively influence one's own cognitive and physiological states. Despite its potential beneficial clinical effects, for example in reducing chronic pain, autosuggestion has gained little scientific attention so far. Here, we tested the effects of autosuggestion on tactile amplitude perception using an implicit measure. In the experimental design, we made use of a known interaction effect between amplitude and frequency perception in touch. We asked participants to manipulate their perception of the strength of touch via autosuggestion and tested the indirect effect on frequency perception (implicit measure). Participants received two touches, first on their left (reference) and second on their right (test) index finger. The main task was to indicate if the touch on the test finger was higher or lower in frequency than the touch on the reference (baseline condition). In the autosuggestion condition, participants were asked to perceive the touches on the reference finger as very strong (Experiment 1) or very weak (Experiment 2), which we expected to influence frequency judgments. We found that that frequency perception was lower at the test finger in the autosuggestion compared to the baseline condition when participants were asked to perceive the reference touch as stronger as possible (Experiment 1), suggesting that autosuggestion was effective in altering participants tactile perception. In Experiment 2, frequency perception was significantly higher at the test finger, when participants were asked to perceive the reference touch as weaker as possible. Unexpectedly, the reverse effect was found for those participants who show a reverse coupling between amplitude and frequency. Our results suggest that autosuggestion is effective in altering participants frequency perception, most likely via their internal change in amplitude perception. More research is needed to explain the effects in participants with reversed response trends.

Delays in a virtual tracking task are detrimental to the feelings of ownership and agency

Stephens, Joey[1]; Hibbard, Paul[1]; van Dam, Loes[2]
[1]University of Essex, United Kingdom; [2]TU Darmstadt, Germany;

The feeling of ownership, such as the perception of ownership of an avatar in virtual reality (VR), can be induced through multisensory correspondences between the senses. These are generated when making active body movements and visually observing our own movements at the same time in the virtual world. Feedback delays, which destroy this correspondence, are detrimental to the feelings of avatar ownership and agency in VR. Here we investigated the mapping between the delay, behavioural task performance and the ratings for ownership and agency. In particular we were interested in the degree to which reductions in ratings of ownership and agency with increasing delay are related to the increased spatial tracking errors and tracking lags that this introduced.

Participants performed a target-tracking task with various delays. The target object was a sphere that moved in three dimensions and participants controlled a second virtual ball to track the target. Delays of 0, 150, 300, 450, 600 or 900 milliseconds between the participants' hand movements and the virtual movements were introduced. No-delay trials were interleaved to avoid potential adaptation effects from influencing the results. After each trial, participants rated their feelings of ownership and agency using a sliding scale, which was presented in the virtual environment.

The results show that with increasing delay both spatial tracking error and tracking lag increased as expected (i.e., task performance decreased). In a similar fashion, the ratings for ownership and agency decreased with increased delay, and were both negatively correlated with the spatial tracking error and tracking lag. These results indicate that task performance and subjective ratings are similarly affected by the delay. This raises the question of whether the subjective ratings might be linked to perceived task performance which will be the focus of future work.

Flight of Mind – Multisensory & sensorimotor mechanisms underlying out-of-body experience Context

Song, Myeong Seop[1,3]; Betka, Sophie[1]; Lance, Florian[1]; Herbelin, Bruno[1]; Blanke, Olaf[1,2]
[1]Swiss Federal Institute of Technology, Geneva, Switzerland; [2]University Hospital Geneva, Switzerland; [3]Seoul National University, South Korea;

As mechanisms of Out-of-Body Experiences (OBEs) are still unclear, we developed a new immersive mixed-reality system, aiming at experimentally inducing OBE-like mental states, to investigate their underlying processes. Using the innovative system, 32 healthy individuals experienced four virtual OBE-like scenarios using a 2 by 2 factorial design with seen body view (mirror & upside-down) and spatialization of sound cue (spatial & non-spatial) as conditions. To measure participants' subjective experience and self-location, a questionnaire and a mental ball drop task were performed after each condition. Also, exploratory analyses explored the impact of preference for the seen body and of awareness of the spatial sound on such measures. We found that all conditions induced more OBE-like mental states, compared to the first-person viewpoint experience. Moreover, the preferred condition and the spatial sound in the spatial sound aware group led to stronger OBE-like sensations and higher self-location. In conclusion, we describe the new mixed reality system that is able to induce OBE-like mental states; such states seem to depend on conscious and multisensory factors. Altogether our results highlight the importance of considering inter-individual variabilities in future OBE studies.

Listen to your fake hand: the effect of sound on the somatic rubber hand illusion

Tammurello, Carolina[1,2]; Amadeo, Maria Bianca[1]; Campus, Claudio[1]; Setti, Walter[1]; Tonelli, Alessia[1]; Gori, Monica[1]
[1]Italian Institute of Technology, Genoa, Italy; [2]University of Genoa, Genoa, Italy;

There are only so many coincidences that the brain is prepared to accept. In the classical rubber hand illusion (RHI), simultaneous stroking of one's hidden hand and a visible dummy hand induces a remapping of the real hand's position towards the fake one, and vice-versa. The RHI has been widely used to show how conflicting sensory information can be integrated into a unitary percept, when certain constraints are met. For instance, the stimuli applied on the real and the fake hand need to be synchronous and spatially consistent to be experienced as the same event. While this makes the RHI a valuable tool for studying multisensory integration, most of the studies have focused on the interplay of vision, touch, and proprioception. The role of audition has remained relatively unexplored. Here, we readapted a somatic version of the RHI paradigm to test the effect of auditory stimulation in phase with the brushstrokes. A group of blindfolded adult participants was asked to estimate the position of their right hand before and after periods of synchronous stimulation. The stimulation could be either tactile or audio-tactile. In the tactile-only condition, the experimenter brushed the participant's right hand while synchronously guiding the participant's left hand to brush the dummy hand. In the audio-tactile condition, a synchronous burst of white noise accompanied each brushstroke; the sound source was placed either on the dummy or on the real hand. We found preliminary evidence that auditory stimulation in phase with the strokes increases the illusion. This finding supports the hypothesis that temporally coherent auditory stimulation may be used to boost the integration of tactile, motor, and proprioceptive signals.

Patterns of spontaneous body exploration in infancy

Khoury, Jason Achille Michel; Popescu, Sergiu Tcaci; Marcel, Valentin; Gama, Filipe; Hoffmann, Matej
Czech Technical University in Prague, Faculty of Electrical Engineering, Czech Republic;

In the first months of life, infants frequently spontaneously touch their body (DiMercurio et al., 2018). These self-touch events constitute an opportunity to detect and learn contingencies between their movements and the resulting tactile and proprioceptive sensations. Learning these contingencies may be critical in the emergence of the body know-how (Jacquey, Fagard, O'Regan & Esseily, 2020) and provide a scaffold for infant reaching and grasping abilities (Corbetta, 2021). Our goal is to quantitatively characterise the "intermodal redundancies, temporal contingencies, and spatial congruence of self-perception" (Rochat 1998). Spontaneous behaviour of two infants at their homes was video recorded longitudinally, from 8 to 23 weeks of age. Our results are twofold, methodological and experimental. First, we refined and tested a procedure that combines recent open-source software tools such as OpenPose and SMIL/Simplify in order to extract 3D motion data directly from videos. We provide guidelines and an integrated software framework for the developmental researchers to reuse our technique. Second, we combined quantitative and qualitative analyses of infant movements to investigate patterns of spontaneous body exploration. Our analyses converge and support an expansion of exploration towards external space in parallel with a progression from upper to lower body areas, as well as an increase in midline crossing. We also explored two candidate markers of goal-orientedness in infant movements: 1) the deceleration of reaching movement before self-touch, which should occur if infants anticipate a contact, and 2) the non-random spatiotemporal distribution of exploratory actions, that should be observed at a fine time resolution of several minutes as learning to reach a specific body part occurs. Our results will allow developmental researchers to process existing and new infant videos in order to investigate kinematic patterns of infant movements, including the development of spatial characteristics and goal-relatedness of infant actions.

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Shahzad, Iqra[1]; Occelli, Valeria[2]; Mouraux, André[1]; Collignon, Olivier[1,3,4]
[1]Université catholique de Louvain, Belgium; [2]Edge Hill University; [3]The Sense Innovation and Research Center; [4]University of Trento;

The representation of touch on our body is not veridical. For instance, tactile distances across the limb (mediolateral) are always perceived as larger than those running along the limb (proximodistal). This tactile anisotropy reflects distortions in body-shape representation, such that the arms are perceived wider than they are. It has been suggested that such an effect may arise because the primary somatosensory representation of touch is rescaled into an object-centered space according to the visual experience of the body. To causally test the role of visual experience on body map representation, we investigated tactile distance perception in sighted and early blind individuals comparing mediolateral and proximodistal tactile distances of stimuli presented on the ventral and dorsal part of their arm, wrist, and hand. Overestimation of distances in mediolateral over proximodistal body axes was found in both sighted and blind people. However, the magnitude of the anisotropy was significantly reduced in the arms of blind people. We conclude that tactile distance perception is mediated by similar mechanisms in both sighted and blind people but vision partly affects the transformation of somatosensory representations into an object-centered space.

The impact of joint attention on the sound-induced visual illusions

Battich, Lucas[1,4]; Garzorz, Isabelle[1]; Wahn, Basil[2]; Deroy, Ophelia[1,3]
[1]Ludwig-Maximilians-Universität München, Germany; [2]University of British Columbia, Canada; [3]University of London, UK; [4]PSL University, France;

We effortlessly engage with others in activities that require attending together to objects and events: we play tennis, sing, walk or hunt together. The multisensory character of these activities requires the selection and integration of information from different senses in a social setting. According to a prevalent hypothesis, joint attention enhances visual information encoding and processing, over and above individual attention. If two individuals jointly attend to the visual components of an audiovisual event, this should affect the weighing of visual information during multisensory integration. We tested this prediction in this preregistered study (N = 49) using sound-induced flash illusions, where an incongruent number of visual flashes and auditory beeps results in a single flash being perceived as two (fission illusion) and two flashes as one (fusion illusion). In the individual condition, each participant performed the flash counting task alone, while in the joint attention condition, two participants sitting next to each other performed the same task concurrently. A control condition was used to discard the possibly arousing effect of mere social presence, with two participants sitting together but one performing a different task. We expected participants to be less prone to both fission and fusion illusions when they jointly attended to the visual targets than when alone. However, illusions were as frequent when people attended to the flashes alone or with someone else, even though they responded faster during joint attention. Sensitivity and bias analysis revealed that participants' response bias in the fusion illusion decreased when engaging in joint attention, compared to other social conditions. Our study reveals the limitations of the theory that joint attention enhances visual processing as it does not strongly affect temporal audiovisual integration, and provides grounds for comparing social effects on temporal and spatial multisensory processes.

Auditory Time to Contact Estimation and The Crucial Role of Temporal Cues

INCE, MELIS[1,2]; BOLLINI, ALICE[1]; CAMPUS, CLAUDIO[1]; GORI, MONICA[1]
[1]Italian Institute of Technology, Italy; [2]Humboldt-Universität zu Berlin, Germany;

The brain continuously perceives and analyses information from the environment to predict and coordinate movements. Estimating Time to Contact (TTC) is a complex task but necessary to predict, for example, the interaction between objects or persons. It has been demonstrated that in the visual domain, humans not only use both kinematic and temporal information but automatically combine them to derive more accurate estimates of TTC. In the current study, we aimed to identify whether the combination of kinematic cues, such as velocity from the auditory source and temporal cues, such as the stimulus duration, also improves the accurate estimation of TTC in the auditory domain. To this goal, we devise a novel auditory task consisting of variations of a moving sound in an array of speakers located in front of the participant. Participants were asked to estimate TTC using either the temporal cues or kinematic cues, additionally by combining these cues in auditory motion perception.

Contrary to previous studies on the visual domain, when the task requires relying on both temporary and kinematic cues, the participants performed worse in estimating TTC, although more consistent than the only kinematic or temporal cues. Our results suggest that TTC estimation bias is not different between only kinematic and only temporal tasks. To conclude, our study presents evidence that while vision relies on the combination of kinematic and temporal cues for higher accuracy in TTC estimation, there is a certain level of integration of the cues in auditory perception. Additionally, we found that it is possible to interpret the combination task using the temporal cues; however, the utility of the interaction might be open to argument as the accuracy is lowest in the combination task. Finally, we suggest that temporal cue is a critical component in TTC estimation in auditory motion perception.

Five Experiments, Including a Pre-Registered Replication, and Mini Meta-Analyses Find No Evidence That Sound-Shape Associations Modulate Audiovisual Temporal Order Judgements

Sourav, Suddha[1]; Röder, Brigitte[1]; Ambsdorf, Franka[1]; Melissari, Andromachi[2]; Arvaniti, Miketa[2]; Vatakis, Argiro[3]
[1]University of Hamburg, Hamburg, Germany; [2]University of Athens, Athens, Greece; [3]Panteion University of Social and Political Sciences, Athens, Greece;

Sound-shape associations (SSA), for example the association of angular shapes with high-pitched tones, and of round shapes with low-pitched tones, have been widely observed in humans across ethnicities. Reported to arise before conscious awareness (Hung, Styles, & Hsieh, 2017), an automatic binding of congruent stimuli across sensory modalities has been suggested for SSA. A hypothesis posits that if congruent sounds and shapes are more robustly integrated, it might be more difficult to distinguish such sounds and shapes in time compared to crossmodally incongruent stimuli. In line with this hypothesis, a highly cited work by Parise and Spence (2009, n=12) reported worse temporal order judgement (TOJ) performance for audiovisual stimuli with congruent compared to incongruent SSA. Here, we report the results of five studies across two labs, including a preregistered replication study (https://aspredicted.org/VNB_ZYQ), all failing to replicate the original results (total n=102). An inverse-variance random-effects meta-analysis of the studies indicated no significant effect of SSA on TOJ performance, with a negligible effect size (β_{SSA} = -0.004, $CI_{95\%}$ = [-0.056, 0.048], p = .880), corresponding to a -0.4% change of the just noticeable difference (JND) metric of TOJ performance. A Bayesian individual participant data meta-analysis likewise found no support against the null hypothesis, and a minuscule effect size, lognormal model, BF_{10} = 0.034, β_{SSA} = -0.009 (-0.89% Δ_{JND}), 95% credible interval ($CrI_{95\%}$) = [-0.074, 0.056]). These results did not substantially change with the inclusion of Parise and Spence (2009) data, BF_{10} = 0.046, β_{SSA} = -0.027 (-2.66% Δ_{JND}), $CrI_{95\%}$ = [-0.088, 0.034], with 77% probability of less than 5% Δ_{JND} given the data. The results indicate that TOJ performance is unlikely to be affected by SSA, suggesting that SSA might arise at a later (or parallel) processing stage compared to the processing of TOJ across the auditory and visual modalities.

The Effect of Action on the Shape of Audio-Visual Temporal Binding Window

Jagini, Kishore Kumar; Sunny, Meera Mary
Indian Institute of Technology Gandhinagar, India;

Our senses are bombarded with several distinct sensory stimuli at any given moment in our daily lives. For a coherent and meaningful perception, the multisensory stimuli coming from a common causal object or event must be perceptually integrated or bound in the temporal domain. Most previous studies explored the multisensory temporal binding phenomenon when observers passively received the multisensory stimuli. However, our understanding of multisensory temporal binding when observers actively generated the multisensory stimuli by one's motor action is less understood. This study investigated whether and how one's own motor action influences the audio-visual (AV) temporal binding using a binary simultaneity judgment (SJ2) task. In three experiments, in each trial, the AV pair was presented as a consequence of the participant's voluntary keypress action (action condition) or automatically generated by the computer (no-action condition). In experiment 1, the onset of the AV pair was temporally contiguous with action. In experiment-2 and 3, a delay of 1000ms and 500ms was introduced between the action and the AV pair onset, respectively. Experiment 1 results indicated a significantly smaller temporal binding window width for vision-leading trials of AV pair for action compared with the no-action condition. However, there was no significant difference in temporal binding windows for auditory-leading trials of action and no-action conditions. In experiments 2 and 3, when the delay was introduced between the action and AV pair, no significant differences were observed for temporal binding window widths of either vision-leading or auditory-leading trials for action and no-action conditions. We interpreted these patterns of results from the Bayesian framework of sensory reliability-weighted binding mechanisms.

Tuesday Afternoon Talks

Tuesday Talks

1:15pm - 2:45pm

Room Danube

The Multisensory Brain

1:15pm - 1:30pm

Common neuronal assemblies integrate emotion expressions from the face and the voice

Barbero, Francesca M.[1]; Talwar, Siddharth[1]; Calce, Roberta P.[1]; Rossion, Bruno[2,3]; Collignon, Olivier[1,4,5,6]
[1]University of Louvain, Belgium; [2]Université de Lorraine, Nancy, France; [3]Université de Lorraine, France; [4]University of Trento, Italy; [5]HES-SO Valais-Wallis, Switzerland; [6]The Sense Innovation and Research Center, Lausanne and Sion, Switzerland;

Effective social communication depends on the integration of emotion expressions coming from the face and the voice. Although there are brain regions that respond more to multimodal than unimodal emotion expressions, these activations could either reflect the activity of multimodal neurons or the summed responses of visual and auditory neurons that coexist in the same region. Multi-input frequency tagging of electrophysiological (EEG) brain responses might reveal a unique non-invasive technique to investigate whether there are neuronal populations that simultaneously process and integrate facial and vocal emotion expressions. We acquired EEG recordings while participants attended to dynamic fearful facial and vocal expressions tagged at different frequencies (f_V, f_A). We were not only able to observe responses at the facial and vocal emotion presentation frequencies, but also at intermodulation frequencies (IMF) arising at the sums and differences of the harmonics of the stimulation frequencies ($mf_V \pm nf_A$) indicating integration of the visual and auditory emotion information into a unified representation. These IMF were not present in the signal and therefore arise only if neuronal populations integrate signal from the two sensory streams. Interestingly, IMF responses were absent in a control condition with mismatched facial and vocal emotion expressions. Our results provide for the first time a direct and non-invasive evidence in support for the existence of neuronal populations that simultaneously process and integrate emotion information from the face and the voice.

1:30pm - 1:45pm

Selective responses to event timing are highly modality-specific

van Ackooij, Martijn[1]; Paul, Jacob M.[2]; van der Zwaag, Wietske[3]; van der Stoep, Nathan[1]; Harvey, Ben M.[1]
[1]Utrecht University, The Netherlands; [2]Melbourne School of Psychological Sciences, Australia; [3]Spinoza centre for Neuroimaging, Netherlands;

Introduction: When we perform complex tasks such as playing instruments or dancing with a partner, we rely heavily on integrating temporal information from different sensory modalities. Neural responses to visual event duration and rate have recently been described, organised in an extensive network of topographic maps. However, it remains unclear whether neural responses to event timing are modality specific. Does this visual event timing network also respond to auditory event timing? Methods: Six subjects were presented stimuli which gradually varied in duration and rate, while recording ultra-high field (7T) fMRI data. This was repeated for auditory and visual stimuli on different days. A voxel-wise population receptive field was modelled as a response to changes in duration and rate. Locations of regions with high variance explained of the best fitting models were compared between modalities to compute overlap scores. Results: Selective responses to visual event duration were observed in a network consisting of regions in the lateral occipital cortex, superior parietal lobule, precentral and postcentral sulci. Selective responses to auditory event duration were observed in a network including the belt and parabelt regions surrounding the primary auditory cortex, regions of the superior temporal gyrus bordering the auditory association areas, and regions of the middle temporal gyrus. Little overlap between these two networks was observed. Selective responses to both visual and auditory timing were observed in posterior sites of the superior temporal sulcus. Conclusion: We observed that most regions responding selectively to event duration and rate are modality specific. This suggests a tight coupling between modality specific processing hierarchies, and the temporal dynamics of their inputs. Only one site contained selective responses to multiple modalities. Further research might elucidate the specific role of this region in multimodal temporal information processing.

1:45pm - 2:00pm

Hierarchical transformation of visual event timing representations in the human brain: response dynamics in early visual cortex and timing-tuned responses in association cortices

Hendrikx, Evi[1]; Paul, Jacob M.[1,2]; van Ackooij, Martijn[1]; Fracasso, Alessio[3,4]; Dumoulin, Serge O.[1,4,5]; van der Stoep, Nathan[1]; Harvey, Ben M.[1]
[1]Utrecht University, Netherlands; [2]University of Melbourne, Australia; [3]University of Glasgow, UK; [4]Spinoza Center for Neuroimaging, Netherlands; [5]VU University, Netherlands;

Quantifying the timing (duration and frequency) of brief visual events is vital to human perception, multisensory integration and action planning. For example, this allows us to follow and interact with the precise timing of speech and sports. Here we investigate how visual event timing is represented and transformed across the brain's hierarchy: from sensory processing areas, through multisensory integration areas, to frontal action planning areas. We hypothesized that the dynamics of neural responses to sensory events in sensory processing areas allows derivation of event timing representations. This would allow higher-level processes such as multisensory integration and action planning to use sensory timing information, without the need for specialized central pacemakers or processes. Using 7T fMRI and neural model-based analyses, we found responses that monotonically increase in amplitude with visual event duration and frequency, becoming increasingly clear from primary visual cortex to lateral occipital visual field maps. Beginning in area MT/V5, we found a gradual transition from monotonic to tuned responses, with response amplitudes peaking at different event timings in different recording sites. While monotonic response components were limited to the retinotopic location of the visual stimulus, timing-tuned response components were independent of the recording sites' preferred visual field positions. These tuned responses formed a network of topographically organized timing maps in superior parietal, postcentral and frontal areas. From anterior to posterior timing maps, multiple events were increasingly integrated, response selectivity narrowed, and responses focused increasingly on the middle of the presented timing range. These results suggest that responses to event timing are transformed from the human brain's sensory areas to the association cortices, with the event's temporal properties being increasingly abstracted from the response dynamics and locations of early sensory processing. The resulting abstracted representation of event timing is then propagated through areas implicated in multisensory integration and action planning.

2:00pm - 2:15pm

Local field potentials and single-units reflect multisensory integration in the medial pulvinar

CAPPE, Céline[1]; VITTEK, Anne-Laure[1]; JUAN, Cécile[1]; GAILLARD, Corentin[2]; MERCIER, Manuel[3]; NOWAK, Lionel G.[1]; BEN HAMED, Suliann[2]; GIRARD, Pascal[1]
[1]Université Toulouse III Paul Sabatier, Toulouse, France; [2]Université Claude Bernard Lyon I, France; [3]Aix Marseille Univ, INSERM, Marseille, France;

The pulvinar is the largest thalamic nucleus in primate. It is anatomically and functionally heterogeneous and can be subdivided in multiple subdivisions, one of which is the medial pulvinar. The medial pulvinar is densely connected with the cortex, specifically with the primary visual, auditory and somatosensory cortices, as well as with the multisensory parietal, temporal and prefrontal associative cortices and the premotor cortex. Based on its anatomical connectivity, the medial pulvinar is proposed to play an important role in the integration of information from multiple sensory modalities. However, evidences in this respect are sparse. In the present work, two macaque monkeys were trained to perform a fixation task while single-units and local field potentials (LFP) were recorded in the medial pulvinar. The monkeys had to maintain fixation on a central point during the presentation of a visual stimulus, an auditory stimulus or both together. Single-units (n = 213) revealed the presence of visual, auditory and audiovisual neurons. Audiovisual neurons accounted for almost half of the neurons. Multisensory integration was mainly sub-additive and suppressive. LFP (n = 163) were analyzed in the time domain and in four frequency bands. In the time domain, we obtained specific evoked potentials for every stimulus conditions at the population and individual levels. The frequency analysis showed a distinction between low and high frequencies. The two low frequency bands (4.5-8.5 Hz and 8.5-20 Hz) were strongly multisensory (respectively 90% and 96% of the sessions) and very similar (109 sessions classified identically). On the contrary, high frequencies (35-60 and 60-120 Hz), were distributed between unisensory and multisensory responses. These results suggest the existence of a frequency coding for multisensory information. In conclusion, our study shows that the medial pulvinar is indeed a multisensory hub, multiplexing visual, auditory, and audiovisual information, which are characterized by different frequency rhythms.

2:15pm - 2:30pm

MVPA classification of natural sounds in early visual cortex

Pollicina, Giusi[1]; Dalton, Polly[1]; Vetter, Petra[2]
[1]Royal Holloway, University of London, UK; [2]University of Fribourg, Switzerland;

A high number of feedback connections link early visual cortex to several other cortical areas. Among these, feedback sent by auditory cortex is sufficient to produce distinguishable neural activity in early visual cortex when participants listen to different natural sounds in the absence of visual stimulation or sight (Vetter, Smith & Muckli, 2014, Current Biology; Vetter, Bola et al., 2020, Current Biology). However, the content of this flux of information has not been fully explored yet. Our study focused on understanding to what degree of specificity auditory information is fed back to visual cortex. We presented a large sample of sounds to 18 blindfolded participants while acquiring functional MRI data. 36 natural sounds were selected according to different semantic categories (e.g. animate sounds, divided into humans and animals, divided into specific species or types of sound, and the same for inanimate sounds). The boundaries of V1, V2 and V3 were drawn using individual retinotopic mapping. We analysed the fMRI activity patterns produced by these sounds in each early visual region using Multivoxel Pattern Analysis (MVPA). Results showed that the MVPA classifier could distinguish significantly above chance animate from inanimate sounds, as well as between human, animal, vehicle and object sounds in early visual cortex. Pairwise classification demonstrated that sounds produced by humans were generally better distinguished compared to other semantic categories. Searchlight analyses showed that decoding also worked in regions of higher level visual and multisensory processing. These results suggest that auditory feedback relays categorical information about sounds, particularly human sounds, to areas that were once believed to be exclusively specialised for vision. We conclude that early visual cortex function is not restricted to the processing of low-level visual features, but includes representation and potential employment of semantic and categorical sound information, which might be used to predict visual stimuli.

2:30pm - 2:45pm

Structural and functional network-level reorganization in the coding of auditory motion directions and sound source locations in the absence of vision

Battal, Ceren[1,2]; Gurtubay-Antolin, Ane[1]; Rezk, Mohamed[1]; Mattioni, Stefania[1,2]; Bottini, Roberto[2]; Bertonati, Giorgia[2]; Occelli, Valeria[2,6]; Maffei, Chiara[3]; Jovicich, Jorge[2]; Collignon, Olivier[1,2,4,5]
[1]UCLouvain; [2]University of Trento, Italy; [3]Massachusetts General Hospital and Harvard Medical School, USA; [4]HES-SO Valais-Wallis, Switzerland; [5]The Sense Innovation and Research Center, Switzerland; [6]dge Hill University, Lancashire, UK;

hMT+/V5 is a region in the middle occipito-temporal cortex that responds preferentially to visual motion in sighted people. In case of early visual deprivation, hMT+/V5 enhances its response to moving sounds. Whether hMT+/V5 contains information about motion directions and whether the functional enhancement observed in the blind is motion specific, or also involves sound source location, remains unsolved. Moreover, the impact of this crossmodal reorganization of hMT+/V5 on the regions typically supporting auditory motion processing, like the human Planum Temporale (hPT), remains equivocal. We used a combined functional and diffusion MRI approach and individual in-ear recordings to study the impact of early blindness on the brain networks supporting spatial hearing, in male and female humans. Whole-brain univariate analysis revealed that the anterior portion of hMT+/V5 responded to moving sounds in sighted and blind people, while the posterior portion was selective to moving sounds only in blind participants. Multivariate decoding analysis revealed that the presence of motion directions and sound positions information was higher in hMT+/V5 and lower in hPT in the blind group. While both groups showed axis-of-motion organization in hMT+/V5 and hPT, this organization was reduced in the hPT of blind people. Diffusion MRI revealed that the strength of hMT+/V5 – hPT connectivity did not differ between groups, whereas the microstructure of the connections was altered by blindness. Our results suggest that the axis-of-motion organization of hMT+/V5 does not depend on visual experience, but that blindness alters the response properties of occipito-temporal networks supporting spatial hearing in the sighted.

Tuesday Afternoon Talks

Tuesday Talks

3:15pm - 4:45pm

Room Danube

Time, Space and Motion

3:15pm - 3:30pm

Movement-induced bias in auditory spatial perception

Locke, Shannon M.[1]; Martolini, Chiara[2]; Lunghi, Claudia[1]; Lancelin, Denis[1]; Cappagli, Giulia[2]; Gori, Monica[2]; Mamassian, Pascal[1]
[1]PSL University, CNRS, Paris, France; [2]Istituto Italiano di Tecnologia, Italy;

When an object is moving, its perceived initial and final positions are spatially biased in the direction of motion. Such biases are known as the Fröhlich and Representational Momentum (RM) effects, widely studied in the visual domain but rarely in auditory domain. It has been argued that the discrimination of onset and offset of a moving sound might depend on a combination of motion direction and stimulus velocity. Nonetheless, the influence of temporal cues of auditory motion is still unclear. The present study aims to establish whether a moving sound would produce a localization bias in the discrimination of sound's onset, offset or both, and whether the combination of target velocity and direction of auditory motion would impact on localization behavior. Twenty-five adults participated in a static calibration task (all participants), and either a Fröhlich (fifteen participants) or RM (ten participants) effect tasks, where they reported either the onset or the offset of a moving sound, respectively. Auditory stimuli were provided through 18 loudspeakers covered with 4x4 tactile sensors arrays, placed inside a fixed 120° arc mechanical support. Participants performed three experimental blocks with constant target speeds (20°/s, 30°/s, 40°/s), where they had to touch either the location of perceived onset or offset after the moving sound had been presented. Our findings highlighted a strong Fröhlich effect (Cohen's d = 1.22) but a weaker (Cohen's d = 0.20) and opposite to motion direction Representational Momentum effect, with no impact of target velocity on both effects, while leftward direction of motion caused a higher bias. Temporal reactions in the Fröhlich task decreased with target velocity, while RM task did not show the same linear result. Our work suggests that spatiotemporal components on an auditory moving stimulus might induce not only spatial biases but also temporal reactions in the direction of motion.

3:30pm - 3:45pm

Parsing response times in multisensory decisions: the effect of signal strength and effector organ

Otto, Thomas U.; Innes, Bobby R.
University of St Andrews, United Kingdom;

Parsing the processing architecture of mental operations and understanding how different components contribute to response times (RTs) are fundamental questions in perception and cognition. For example, the additive factors methodology has contributed to propose sensory processing, decision making, and motor response as consecutive stages. Here, we extend this approach to multisensory processing as tested in the redundant signals paradigm. In two unisensory conditions, either an auditory or a visual signal is presented. In a third redundant signals conditions, both signals are presented simultaneously. The task is to respond in all conditions with the same motor act. As one of the most prominent benefits of multisensory processing, the typical finding is that RTs to redundant signals are faster compared to the unisensory components. The speed-up is well explained by so-called race models, assuming two parallel decision units coupled by a logic OR-gate. Interestingly, this model architecture allows to design experimental manipulations that selectively target processing components either before or after the proposed OR-gate, which leads to distinct predictions on the level of RT distributions. We tested these predictions using a 2x2 design with factors signal strength (low vs. high; "before") and motor response (hand vs. foot; "after"). Both factors were highly effective in unisensory conditions, leading to joint RT differences of about 200ms. Critically, the speed-up of RTs in all four redundant signals conditions followed the model predictions remarkably well. We use these findings to argue that the proposed OR-gate can be highly informative to parse the time between stimulus onset and response, and in consequence to understand the processing architecture involved in multisensory decisions.

3:45pm - 4:00pm

Auditory and Tactile Stimulation Selectively Increases the Perceived Speed of Visual Objects

Meyerhoff, Hauke S.[1]; Gehrer, Nina A.[2]; Merz, Simon[3]; Frings, Christian[3]
[1]University of Erfurt; [2]University of Tübingen, Germany; [3]University of Trier, Germany;

We present a new crossmodal illusion demonstrating that temporal coincidence of visual and auditory/tactile stimuli changes speed perception of a visual object. Our visual stimuli consist of two discs moving within the left and the right half of the screen. Each object changed its direction of motion, however, the direction changes of one of the objects were accompanied by spatially uninformative stimuli (tones/vibrations). Whereas the audio/tactile-visual object moved at a constant speed of 4.5 deg, the speed of the visual object varied from 2.75 to 6.25 deg. Importantly, the non-visual stimuli were irrelevant for the participants who only judged which of the two objects moved faster. We measured the point of subjective equality, which indicated that the audio/tactile-visual object was perceived to move 6-9% faster than the visual object. The effect persisted with prevented eye-movements and across different volumes. We investigated the spatial nature of this illusory increase in speed by comparing the effect of the coincident non-spatial tones with a condition in which the disc flashed in red color at the same timing. Both manipulations induced the same illusory increase in object speed, however, a flashing frame around the entire scene (i.e. pure visual coincidence) did not. Thus, we argue that the increase in perceived speed stems from guidance of spatial visual attention elicited by an enhancement due to the temporally coincident non-spatial sounds. The illusion also emerges with spatially incongruent sounds further emphasizing the importance of temporal rather than spatial congruency. As the illusory increase in speed is equally pronounced following non-spatial tactile stimulation (simultaneously to both wrists), we presume that the illusion emerges from effects of cross-modal integration on spatially selective visual attention rather than early sensory interactions.

4:00pm - 4:15pm

A direct comparison of cue combination with familiar and newly-learned cues

Scheller, Meike; Aston, Stacey; Slater, Heather; Nardini, Marko
Durham University, United Kingdom;

Our ability to effortlessly perceive and navigate a three-dimensional world is grounded in our efficiency at using multiple sensory cues that provide redundant information about the same physical property. Depth perception, specifically, relies on the combination of multiple different cues, such as stereo, motion and texture, to gauge the distance of objects in space. Typically, such familiar depth cues are combined in accordance with their sensory reliabilities. This leads to an increase in perceptual precision and allows integration to flexibly adjust to noisy environments. Furthermore, these cues may become prone to mandatory, partial or full fusion. However, whether these three functional features (precision enhancement, re-weighting, and fusion) occur only with highly familiar cues, or can emerge to the same extent with a completely novel cue to depth after short training is still unclear. This study presents data from a depth discrimination task that measured these properties of cue combination for familiar-familiar and familiar-novel pairs of cues. Over four sessions, participants experienced three different depth cues, presented either alone, in combination as a familiar-familiar pairing (binocular disparity, size), or as a familiar-novel pairing (binocular disparity, auditory pitch). Preliminary data from 6 participants shows precision increases, re-weighting and partial fusion in both types of cue pairings, with stronger effects for familiar-familiar pairings. This suggests that all three functional features of cue integration can be established quickly in adulthood and with minimal training, however, the efficiency of each process may hinge on the amount of experience. While more data will be required to draw more definite conclusions, this first direct within-participant comparison of familiar and novel cue combination will provide a testbed for comparing the cognitive and neural mechanisms involved in the two cases. Better understanding mechanisms for efficient cue combination via alternative cues can inform enhancement and rehabilitation of human perception.

4:15pm - 4:30pm

Modeling the effects of attention on causal inference in multisensory perception

Badde, Stephanie; Landy, Michael S
New York University, United States of America;

At any moment in time, streams of information reach the brain through the different senses. Given this wealth of noisy information, it is essential that we select information of relevance — a function fulfilled by attention — and infer its causal structure to take advantage of redundancies across the senses. We tested experimentally whether the distribution of attention across vision and touch enhances cross-modal spatial integration and recalibration compared to modality-specific attention. In both experiments, we found stronger effects of vision on touch under distributed than under modality-specific attention. We have constructed and compared models of these effects to isolate the mechanisms behind attentional modulation. Model comparison confirmed that participants used causal inference to localize visual and tactile stimuli presented as part of a visual-tactile stimulus pair, whereas simultaneously collected unity judgments — indicating whether the visual-tactile pair was perceived as spatially-aligned — relied on a heuristic. The best-fitting model revealed that attention modulated two components of causal inference. Distributed attention led to (1) an increase of sensory noise compared to selective attention toward the reported modality, and (2) increased stimulus-independent expectation that the two signals belong together (i.e., the observer's prior probability of a common source for vision and touch, p_{common}). However, model simulations revealed that only the increase in p_{common} was able to explain the observed enhancement of visual-tactile integration and recalibration effects with distributed attention. In contrast, the change in sensory noise explained only a fraction of the observed enhancements, as its consequences vary with the overall level of noise and stimulus congruency. Our modeling indicates a weak a priori association between visual and tactile spatial signals that can be strengthened by distributing attention across both modalities.

4:30pm - 4:45pm

Modeling audiovisual temporal processing of ecological stimuli

Parise, Cesare Valerio[1]; Kurt, Aykut[1]; Ernst, Marc[2]
[1]Independent scientist; [2]University of Ulm;

Synchrony across the senses is a major factor underlying multisensory integration. Simultaneity and temporal order judgments have been widely used to investigate human multisensory processing and quantify the temporal window of integration. A common finding is a relative widening of perceived simultaneity for ecological stimuli, such as audiovisual speech, compared to minimalistic ones, like clicks and flashes. In the absence of a model to explain that, however, accounts for such effects remain often speculative. In recent years we have started unravelling the computational principles of multisensory temporal processing of minimalistic stimuli. However, the sheer complexity of the signals has so far hindered the application of the same tools to ecological stimuli. Here, we used a combination of psychophysical experiments (temporal order judgments, simultaneity judgments, and two-interval forced-choice simultaneity judgments) to assess human sensitivity to lags between complex audiovisual stimuli, such as speech or a hammer smashing on a surface or a hand hitting a guitar's strings. Next, we fed the same raw audiovisual footage to a pool of spatially-tuned Multisensory Correlation Detectors, integrated their output over time and space, and used this response to predict human performance in each psychophysical task. We found an excellent agreement between human responses and model predictions: the model could even capture stimulus-specific features of the psychometric functions in the absence of stimulus-specific parameter tuning. Besides standing as the first successful quantitative account for the audiovisual temporal perception of ecological stimuli, this study further supports the validity of correlation detection as a general computational principle for multisensory integration.

Tuesday Afternoon Posters

Tuesday Afternoon Posters

4:45pm - 5:45pm

Combined visual-auditory fear-related stimulation delayes the disengagement of spatial attention from an invalidly cued position: an ERP study

Zimmer, Ulrike[1]; Wendt, Mike[1]; Pacharra, Marlene[2]
[1]Medical School Hamburg MSH, Germany; [2]Ruhr University Bochum, Germany;

Spatial shifts of attention evoked by a peripherally presented visual or auditory cue can be enhanced by adding fear-related content, such as the picture of a face displaying an anxious expression or a fearful vocal sound, compared with emotionally neutral cue stimuli (Zhang et al., 2017; Zimmer et al., 2016). We investigated this "emotional enhancement" of attentional cueing by presenting redundant visual-auditory cues (i.e., a neutral or fearful face together with a neutral or fearful voice, located on the same side) which preceded an (emotionally neutral, visual) target stimulus, displayed on the same side (i.e., valid cueing condition) or on the opposite side (i.e., invalid cueing condition) and recorded attention-related ERPs (i.e., P1, P3). In reaction times, a typical cueing validity effect was only observed when both cues were related to fear. Corresponding with this behavioral effect, the P1 displayed a maximum difference between valid and invalid trials in the "both cues fearful" condition. A main effect of validity in the P3a component (i.e., larger P3a in invalidly than in validly cued trials) suggested, however, that spatial attention was first drawn to the cued position for all types of cue combinations. The subsequent P3b displayed a pattern consistent with the notion that redirecting of attention in invalidly cued trials was impaired when both cues were associated with fear. In conclusion, our results suggest that bimodally presented fear-related cues lead to enhanced focusing of attention making it more difficult to disengage attention from the cued location.

Effects of musical expertise and response mapping on pitch-space crossmodal interactions

Wilbiks, Jonathan M.P.; Dincorn, Kailey
University of New Brunswick Saint John;

When assessing the pitch of auditory stimuli, individuals respond more quickly and more accurately when congruent visual stimuli are presented simultaneously. That is to say, visual stimuli higher in space improve performance on high pitches, while low pitches are better processed with visual stimuli presented lower in the visual field (Bonetti & Costa, 2018). These pitch-space interactions can be further modulated by the orientation of a response device; when the response button for a high pitch is higher (and for a lower pitch, lower), responding is improved relative to conditions where response mapping is reversed (Rusconi et al., 2006). Recently, we combined the study of pitch-space interactions in horizontal and vertical planes with response mapping (Klapman et al., 2020) and found that while vertical pitch-space interactions are automatic and exist regardless of response mapping, horizontal pitch-space interactions are only observed when response mapping is also horizontal. The current research examines this effect in a grounded-embodied-situated (GES) perspective (Lachmair et al., 2019). We tested individuals with varying levels of musical sophistication in a context where the response orientation resembled a cello fingerboard (vertically oriented, with keys facing away from the participant), as well as a context where it was horizontal (like a piano). Participants identified the relative pitch of a tone that was presented simultaneously with a visual stimulus that varied in location both vertically and horizontally. While both groups showed the expected vertical pitch-space interaction with vertical response mapping, only those with higher levels of musical sophistication showed horizontal pitch-space interactions with horizontal response mapping. This finding extends previous research on the effects of response orientation and expertise on pitch-space interactions, and could inform applied research in user experience (UX) design. Future research with highly trained cellists should also be conducted to confirm the findings based on the GES framework.

Comparing eye movement-related eardrum oscillations (EMREOs) in subjects with normal hearing and auditory system dysfunction

King, Cynthia[1]; Schlebusch, Stephanie[1]; Kaylie, David[2]; Shera, Christopher[3]; Groh, Jennifer[1]
[1]Duke University, USA; [2]Duke University Medical Center; [3]University of Southern California;

Eye movements are critical to linking vision and spatial hearing – every eye movement shifts the relative relationship between the visual (eye-centered) and auditory (head-centered) frames of reference. This requires constant updating of incoming sensory information in order to integrate the two sensory inputs. Previous neurophysiological studies have revealed eye movement-related modulation of the auditory pathway. We recently discovered a unique type of low frequency otoacoustic emission that accompanies eye movements. These eye movement-related eardrum oscillations (EMREOs) occur in the absence of external sound and carry precise information about saccade magnitude, direction, and timing (Gruters et al 2018, Murphy et al 2020). However, it is not well understood how these eye movement-related effects in the auditory periphery contribute *mechanistically* to hearing. Two auditory motor systems may be involved in generating EMREOs: the middle ear muscles and/or the cochlear outer hair cells. To gain insight into which systems are involved and how they contribute, we are presently investigating the EMREOs in human subjects with dysfunction involving these systems compared to a normal hearing population. The impact of hearing loss on the EMREO is examined by comparing responses from individuals with different hearing pathologies to population data from normal hearing subjects. We find that EMREOs are abnormal in subjects with hearing impairment, most commonly with the EMREO being abnormally small in individuals who have impaired outer hair cell or stapedius function. Future work is needed to assess if patients with these types of hearing loss have specific impairments in the perceptual process of integrating visual and auditory spatial information.

Effect of sensory reliability and saccadic eye-movements on multisensory integration in the spatial ventriloquism paradigm

BELLE, Aurélien[1]; QUINTON, Jean-charles[3]; LEFORT, Mathieu[2]; CHAUVIN, Alan[5]; GUYADER, Nathalie[4]; AVILLAC, Marie[1]
[1]CRNL, France; [2]LIRIS, France; [3]LJK, Grenoble; [4]Gipsa-Lab, Grenoble; [5]LPNC, Grenoble;

In our environment, our senses are continuously exposed to noisy sensory signals thus providing uncertain information about the world. To reduce these uncertainties, we integrate these informations and explore our surroundings through combined eye and head movements (i.e. active perception). Besides, it has been shown that sensory signals are weighted by the reliability of the stimuli (Ernst & Banks, 2002). In the present study we assess the influence of sensory reliability and active perception on multisensory integration in human subjects with psychophysics and eye-tracking approaches. The paradigm is based on the ventriloquist effect. It consisted in the mislocalization of an auditory target when a visual stimulus is presented simultaneously at a different location (Bertelson & Radeau, 1981). The subject task is to localize the auditory target by a mouse click. We tested two visual stimulation sets: 1) a gabor patch within a Gaussian background noise; 2) a cloud of moving dots patch within a random moving dots cloud. Auditory stimulation consisted in a pink-noise stimulus within a constant background white noise. Auditory and visual stimuli are presented at four spatial locations: +/- 4 and 12°. Visual reliability is manipulated by changing dot's density or gabor contrast; auditory reliability by varying sound pressure level. This procedure is conducted in two conditions: passive (fixation) or active condition, participant is performing the same localization task while moving the eyes. It allows us to search for saccadic exploration strategies at work in multisensory integration processes. Our results show that localization error of the auditory stimulus increase when visual reliability is high (i.e. visual capture). Besides, subjects make less localization errors when auditory reliability is elevated (less visual capture). Finally, visual capture is lower in active vs passive condition. Multisensory integration processes depend on auditory and visual reliability and are impacted by saccadic eye movements.

Eye movement-related eardrum oscillations do not require current visual input

Abbasi, Hossein[1]; King, Cynthia D.[2]; Schlebusch, Stephanie[2]; Röder, Brigitte[1]; Groh, Jennifer M.[2]; Bruns, Patrick[1]
[1]University of Hamburg, Hamburg, Germany; [2]Duke University, USA

Recent findings have suggested that information about eye movements affects auditory processing even at the most peripheral stages at the level of the eardrum: Saccades to visual targets elicited eye movement-related eardrum oscillations (EMREOs), which systematically varied depending on the direction and amplitude of the saccade and, thus, might play an important role in aligning auditory and visual spatial representations. EMREOs have been demonstrated in the absence of any auditory stimulation, but it has remained unclear whether their occurrence requires current visual input. Here, we tested the role of visual stimulation for EMREO signals in two experiments in healthy adult human participants. In Experiment 1 (n = 7), participants performed saccadic eye movements from a fixation point to a visual target. In Experiment 2 (n = 20), participants performed free eye movements in a darkened room without any visual or auditory stimulation to test whether the EMREOs are dependent on the presence of visual saccade targets. In both experiments, an eye tracker and in-ear microphones were used to record eye movements and eardrum oscillations, respectively. When the saccadic and eardrum data were aligned with respect to the saccade onset, regression analysis revealed a significant relationship between the eardrum oscillations and horizontal eye movements in both experiments (i.e., independent of current visual input). These results replicate and extend previous findings by showing that the EMREOs do not depend on current sensory input, but are solely prompted by top-down signals from the oculomotor system. This suggests a primary role of EMREOs in auditory coordinate transformations between eye- and head-centered reference frames which would be independent from current visual input.

Tuesday Afternoon Posters

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4:45pm - 5:45pm

How we adjust our movements in response to error feedback when intercepting moving targets

Bertonati, Giorgia[1,2]; Gori, Monica[1]; Brenner, Eli[3]
[1]Istituto Italiano di Tecnologia, Genoa, Italy; [2]Università degli Studi di Genova, Genoa, Italy; [3] Vrije Universiteit, Amsterdam, Netherlands;

When repeatedly intercepting moving objects, the way the arm moves is adjusted based on errors on previous attempts. Here, we examine whether one adjusts the timing or the position of the interception, or both. In particular, we investigate whether what one adjusts depends on the target's speed. To correct for a given spatial error, the timing needs to be adjusted less as the target moves faster, because the same spatial error corresponds with a smaller temporal error for faster targets. Therefore, it would seem logical to rely more on changing the timing for fast targets and more on changing the position for slow targets. To see whether people do this, we asked 24 participants to tap on fast and slow virtual disks that moved rightwards across a screen. Fast and slow targets were presented in separate blocks of trials. In each trial, we introduced systematic spatial errors in the feedback provided to participants by having the target jump a fixed amount, randomly to the left or the right, just before the finger reached the screen. We observed how participants adjusted the interception in the subsequent trial in response to the resulting (additional) interceptive errors. Most participants adjusted both the timing and the position of their movements' endpoint based on the manipulated feedback presented in the previous trial. We found no difference between the two speeds concerning how the spatial error was corrected by changing the interception's timing and position. However, we observed a lot of variability among participants, which makes us believe that other factors than those we intentionally manipulated may have influenced how movements were adjusted in response to error feedback.

Memory task influence on postural stability and self-motion perception in virtual environment

Tixier, Maëlle[1]; Cian, Corinne[1,2]; Barraud, Pierre-Alain[3]; Laboissière, Rafael[1]; Rousset, Stéphane[1]
[1]Univ. Grenoble Alpes, Grenoble, France; [2]Institut de Recherche Biomédicale des Armées, France; [3]Univ. Grenoble-Alpes, Grenoble, France;

The integration of sensory inputs (visual, somatosensory, and vestibular) is an adaptive, dynamic process. The ability to reweight sensory information is important for maintaining stability in different environments. In virtual reality environment (VR), the moving visual field inducing illusory self-motion (vection) provokes conflicts between visual and vestibular sensory cues, which should be resolved by down-weighting of vestibular information. However, during upright stance, the visual inputs that produce illusory self-motion would be inhibited or down weighted, in order to prevent the fall. Postural control in VR is generally accompanied by posture-unrelated cognitive activity. However, balance and cognitive tasks may interfere, particularly when the cognitive task involves spatial processing, increasing the performance costs of one or both of activities. Here, we examine the effects of a moving visual field in postural/memory dual tasks. A random-dot pattern covering the observer's visual field was used. The visual pattern was either static, dots rotated around the center of the screen (vection), or dots rotated with random angular velocities and direction (no vection). Facing these visual displays, standing participants performed either a memory task or no cognitive task. Two different memory tasks were used: an episodic memory task which addresses the capacity to remember a past event and induce an indirect spatial processing through scene construction and a semantic memory task, which refers to general knowledge. The memory tasks were also performed in a seated position. When standing, displacements of the center of foot pressure in the frontal and sagittal planes were registered using a force platform. The main question was whether the moving visual field affect posture in different ways when performing a secondary memory task and whether the visual information interferes more with memory performance in tasks inducing spatial processing. Finally, adaptation to the visual perturbation through repetition of the task was also studied.

Motor Adaptation Distorts Visual Space

Petrizzo, Irene; Anobile, Giovanni; Arrighi, Roberto
University of Florence, Italy;

It has been demonstrated that adapting to self-produced motion induces a compression of both perceived numerosity and duration, suggesting the existence of visuomotor mechanisms that encode numerosity and duration of external as well as internal events. According to the ATOM theory, perception of time and numerosity might also be linked to the processing of spatial information. To test this, we assessed whether motor adaptation also affects the perception of visual space, and compared these results with visual adaptation (to high density texture), known to distort spatial separation. Participants were presented with two dot pairs, in each pair dots were separated by 4° (+/- 0.3°), and presented on either side of fixation. They indicated in 2AFC which pair appeared to be separated by the shorter distance. In the adaptation trials, the stimuli were preceded by a 5-sec presentation of dense visual texture (visual adaptation), or by the participant rapidly tapping in mid-air (motor adaptation) for 6 secs. The effect of adaptation was measured by the shift of PSE before and after adaptation. Our data show that adaptation to self-produced movement induces a significant compression of the perceived spatial separation of the stimuli presented around the tapping location. The magnitude of motor adaptation aftereffects was robust, around 3%, while visual adaptation was around 10%. Importantly, the spatial selectivity of the effects suggests that they do not derive from a decisional bias, but point to spatially selective mechanisms combining motor and visual information. Our results extend previous reports about the interaction of the perceptual and motor systems in the processing of time and numerosity to the processing of visual space. This is in line with the core idea of the ATOM theory of a shared representation for time, numerosity and space that optimizes the combination of perceptual information with motor planning and execution.

The Effects of Stimulus Salience dominate audio-visual Spatial Integration both in children and adults

Storm, Sina; Bruns, Patrick; Röder, Brigitte
Universität Hamburg, Germany;

The localization of an auditory stimulus is influenced by the presence of a simultaneous but spatially displaced visual stimulus, a phenomenon known as the ventriloquist effect. Here we tested whether the typically larger ventriloquist effect in children is due to stronger reliance on bottom-up processes such as use of stimulus salience. In an adapted paradigm from Vroomen et al. (2001), 5-year-old children and adults localized sounds which where flanked by four synchronous cartoon figures, two on each side of the sound sources. Visual stimulus salience was manipulated by reducing the size of one of the two outmost cartoon figures, thereby creating a singleton in size. We hypothesized that bottom-up driven salience rather than singleton-based automatic attention shifts define the ventriloquist effect and that this effect is larger in the children group. Both age groups showed a shift in sound localization away from the side of the singleton, that is, in the direction of the two big (and thus presumably more salient) cartoon figures. However, preliminary evidence did not confirm a larger saliency-based ventriloquist effect in children. In a second phase of the experiment the same visual array was presented without sounds, but with an additional visual target (e.g., apple or banana) on one of the two outmost cartoon figures which participants had to identify via a button press. Compared to a control condition without singleton, both age groups made more errors in target detection when the size singleton was presented on the opposite side of the target, indicating that the singleton attracted their attention. The present results confirm a dissociation between spatial attention (towards the singleton) and the ventriloquist effect (towards the salient big stimuli) in both children and adults and do not confirm that the previously observed larger ventriloquist effect is mainly due to higher visual stimulus salience for children.

The sense of agency and the visuo-vestibular integration in self-motion perception

Rineau, Anne-Laure[1]; Sarrazin, Jean-Christophe[1]; Bringoux, Lionel[2]; Berberian, Bruno[1]
[1]ONERA, France; [2]ISM, France;

Self-motion perception appears to be a key element in the understanding of pilot behavior. In particular, the phenomenon of spatial disorientation (SD) is still today a major factor in the occurrence of accidents. Self-motion perception that is mainly based on visuo-vestibular integration can be modulated by the physical properties of the environment with which humans interact. As illustration, several studies have shown that the respective weight of visual and vestibular information depends on their reliability. More recently, it has been shown that the internal state of the operator can also modulate the multisensory integration. Interestingly, the systems' automation can interfere with this internal state through the loss of the intentional character of the movements (i.e., loss of agency) and the modulation of the predictive mechanisms that accompany it. More broadly, the concept of "active sensing" reflects the impact of top-down mechanisms on perception. In this context, one of the new challenges is to better understand the relationship between automation and self-motion perception. To this end, our first experiment aims at comparing the motion perception threshold for a self-generated longitudinal movement versus a passive movement. The question is asked in vestibular alone, visual alone and visuo-vestibular condition (Results under analysis). In continuity, our second experiment explores the possible interaction between the self-generated movement and its perceived intensity by an intensity comparison task of two movements. In the active condition, the first movement is generated by the participant himself. The question is asked in bimodal condition only. We hypothesize that being an agent of one's own movement may modulate the sensitivity thresholds and slopes of the detection task, or the PSEs and JNDs of the comparison task. The results are discussed in light of agency theory and its predictive mechanisms, according to which being in control of the action modulates human perception.

Tuesday Afternoon Posters

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4:45pm - 5:45pm

Cognitive factors may affect the updating of an object's position during linear lateral translation.

Kim, John Jong-Jin; Harris, Laurence Roy
Centre for Vision Research, York University, Toronto, Canada;

Updating the egocentric positions of surrounding objects during self-motion is fundamental to the daily activities of people interacting and/or avoiding them as they navigate in the world. Despite the importance of this ability, past studies have shown that people make systematic errors when updating during linear self-motions. To update the positions of surrounding objects, a person needs to know their own movement through space, which requires integrating information from multiple senses including visual, vestibular, somatosensory and motor systems. In Exp1, we measured people's updating errors after passive lateral translation (1m) with visual motion cues only (using an Oculus VR HMD while sitting on a stationary chair in an office-like room). Remembered target positions were shifted in the direction of movement. In Exp2, we translated people again (.46m) this time adding physical motion with and without visual cues (using a 6-DOF moving platform in a test room identical to the VR environment) and also visual cues only. However, the updating errors were the same as when they were stationary, when the person moved (either visually, unlike the finding from Exp1, or physically). Were the differences between Exp1 and 2 due to the difference in the travel distance, or the effect of exposure to a moving platform? Therefore, in the present study (Exp3), we looked for updating errors associated with the two visually simulated travel distances (.46m and 1m). With N=9, a main effect of translation was found where their remembered positions shifted in the direction of the movement as found in Exp1 but not in Exp2. This suggests that cognitive factors (sitting on a platform that is known to be able to move) may impact people's updating, making them more accurate at updating the positions of targets that were initially seen before they moved.

Functional connectivity of visual and vestibular cortical regions

Becker, Markus; Frank, Sebastian M.; Beer, Anton L.; Greenlee, Mark W.
University of Regensburg, Germany;

Self-motion sensation relies on the multisensory integration of perceptual cues including vestibular and visual motion cues. Several cortical areas contribute to this multisensory integration and are part of a visual-vestibular cortical network. Here, we examined the intrinsic functional connectivity between different areas of the visual-vestibular network based on resting-state functional magnetic resonance imaging (fMRI) in human participants (n = 30) and quantified these connections by graph theoretical measures. We collected two resting-state fMRI runs while participants either kept their eyes closed or open (while fixating) in alternating order (10 minutes each), as well as task-based fMRI while participants were stimulated with caloric vestibular and visual motion cues. Task-based fMRI was used to localize different areas of the visual-vestibular network. Functional connectivity was then calculated between the nodes of this network. Finally, graph theoretical measures for centrality of the network components as well as its modular structure were assessed. We found significantly stronger functional connectivity between areas in the ventral and dorsal intraparietal sulcus (VIPS/DIPS) and areas 7, premotor area 6v, supplemental motor area (SMA) and frontal eye fields (FEF) during open compared to closed eyes. The cingulate sulcus visual (CSv) area, areas 2v and 3av, FEF, area 6v, as well as the posterior insular cortex (PIC) exerted the highest eigenvector centrality within the network, underlining their involvement in multisensory visual-vestibular processing. With closed eyes, areas that show activation mainly during vestibular stimulation have a higher centrality than during fixation, while this pattern is inverted for areas that are mainly responsive to visual motion, indicating a shift in visual-vestibular processing depending on visual and oculomotor information. The modular structure of the network is best described as a three-module solution, which can be categorized by responsiveness to vestibular and visual motion stimulation and does not change between closed and open eye conditions.

Gravity vs Anti-gravity: can the Self-Motion-Induced Bias in Time-to-Contact Estimation be reversed?

Joerges, Bjoern; Harris, Laurence Roy
Center for Vision Research, York University, Canada;

We recently showed that visually-simulated self-motion can bias the perceived speed of an object in the observer's environment [1]. Visually simulating self-motion creates a multisensory conflict between visual cues and the vestibular, efferent copy and proprioceptive cues that would normally accompany self-motion. Humans can use an internal representation of Earth gravity to time interceptive actions more accurately [2]. If time-to-contact estimates are partially based on a model of gravity, then the perceived speed of an object induced by self-motion should be biased by self-motion less when object motion is consistent with Earth gravity compared to when it is not. We tested this hypothesis by immersing participants in a virtual 3D environment and showing them objects moving along parabolic trajectories in the fronto-parallel plane that were either consistent with Earth gravity or with anti-gravity (pulling upwards). The target disappeared after reaching the peak of its parabolic path and participants indicated when and where it would have hit a target plank. While they were doing this, participants experienced visually simulated self-motion in one of four cardinal directions (up, down, left, right) or remained static. Evidence both for the use of an internal representation of Earth gravity and for an effect of visual self-motion on motion extrapolation was inconsistent across the different experimental conditions. Differences between this experiment and the published literature, which may explain these discrepancies, are discussed.

[1] Jörges, B., & Harris, L. R. (2021). *Attention, Perception, & Psychophysics* [2] Zago, M., McIntyre, J., Senot, P., & Lacquaniti, F. (2008).. *Vision Research*

Does Weber's law hold for self-movement signals that encode self-controlled head rotation?

Haynes, Joshua D.; Gallagher, Maria; Culling, John F.; Freeman, Tom C.A.
Cardiff University, United Kingdom;

Self-movement causes changes in the flow of information within sensory images. To achieve perceptual stability, many theories propose that self-movement signals are combined with those encoding image movement, using signal precision to drive the process. Taking head rotation as an example, we developed a novel technique for measuring precision when self-movement is under participant control, as is typically the case. We then used the technique to investigate whether the precision of head-rotation signals scale with head speed (i.e., Weber's law). Our paradigm consists of two experimental phases. In both phases, participants sat inside an LED/speaker ring and judged whether an auditory target moved more in Interval 1 or Interval 2. In the first phase, the stimulus was head-fixed in Interval 1 and the participant performed a self-controlled head rotation. In Interval 2, the participant remained stationary and listened to stimulus motion based on scaled versions of the head movement recordings obtained in Interval 1. In the second phase of the experiment, the auditory motion in both intervals was based on scaled versions of the stored head-movement recordings from the first phase, with stationary participants listening to these within a more standard motion discrimination task. The precision of the head-rotation signal was then estimated by applying the variance sum law of signal-detection theory across the two phases. To investigate Weber's law, participants were trained to rotate their heads at one of five head speeds prior to each two-phase session. The training was based on an audiovisual target that moved across the LED/speaker ring at 20, 50, 80, 110 or 140 degs/s. Preliminary results suggest that head-rotation signals obey Weber's law for a wide range of head speeds. However, for some participants, Weber's law breaks down at the slower head speeds investigated, yielding substantially higher thresholds than expected.

Effects of a non-informative auditory feedback over touch in the blindness

Casado Palacios, Maria[1,2]; Tonelli, Alessia[1]; Campus, Claudio[1]; Gori, Monica[1]
[1]Italian Institute of Technology; [2]University of Genoa, Italy;

The majority of the research focused on multisensory processing during blindness leads to the conclusion of a reduced audio-tactile interaction in the detection of touch in this population. However, despite the vital importance that active touch (defined as voluntary movements) has in the daily life of blind individuals, this research has been centered predominately on passive touch conditions and/or static stimulation. Because of that, with this work, our goal was to dig into the differences in tactile processing in presence of non-informative auditory information in sighted and blind individuals during dynamic stimuli discrimination, in active touch conditions. With this aim, we measured their velocity discrimination threshold. Using physical wheels, participants were instructed to discriminate the faster stimuli of a sequence of two movements with different speeds while moving their index finger in the opposite direction of the wheel. Two experimental conditions were tested: (1) unimodal tactile, in which the information was provided by the movement of the wheel that was embedded in a sinusoidal greeting; and (2) bimodal audio-tactile, where a non-informative sound was displayed at the same time and with the same duration as the movement. Our results show a significantly worse performance in the bimodal condition in sighted but not in blind individuals. This supports the suggestion of a reduced audio-tactile interaction in the second group that might be caused by automatic activation of internal coordinates due to the lack of visual calibration. In addition, this study allows us to extend said assumption to the conditions of active touch using a dynamic stimulus.

Tuesday Afternoon Posters

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4:45pm - 5:45pm

Naturalistic spatial precision correlates with the left-right discrimination threshold if head and trunk are not aligned

Esposito, Davide[1,2]; Bollini, Alice[1]; Gori, Monica[1]
[1]Istituto Italiano di Tecnologia, Italy; [2]DIBRIS, Università di Genova, Italy;

Spatial orientation is an ability that depends on vestibular and proprioceptive cues. Indeed, the results about spatial orientation abilities obtained in static tasks, such as the thresholds of a discrimination-based psychophysical test, change according to the head-on-trunk orientation. However, it is unclear to which extent those results can be generalized to more complex and dynamic tasks, for example, when participants are free to rotate the head on the trunk. The present study aimed to clarify this issue by comparing the audio-spatial performances of a group of typical adults in a static psychophysical task, the left-right discrimination task, and in a dynamic task, an acoustic archery game. The auditory archery game consisted of a first-person perspective alignment task where the participant was required to shoot the arrow and then guide it using their head toward an acoustic target. The audio-spatial left-right discrimination task was repeated with the head turned at 45° leftward, 0°, and 45°rightward. The study hypothesized that the dynamic setting behavior could be better explained by repeating static psychophysical assessments in different head-on-trunk orientations. The psychophysical thresholds' average explained part of the variance in the virtual archery game, and further analyses suggested that the most significant amount of variance in the virtual archery was explained by averaging the two thresholds obtained with the head turned. Our results indicate that psychophysical assessments of spatial precision with head and trunk aligned are not representative of the precision observed in dynamic settings. This instead should be carried out by averaging the difference thresholds obtained with the head rotated on both sides.

Performing a task jointly reduces interference in a visual and an audiovisual Stroop task

Gearhart-Edwards, Anika[1]; Wahn, Basil[1]; Sinnett, Scott[2]
[1]University of Hawaii at Manoa, USA; [2]University of British Columbia, Canada;

Humans constantly receive multiple stimuli through their different sensory modalities (e.g., audition and vision). These stimuli may or may not be integrated into a unitary percept via a process called multisensory integration. This process becomes more complex when stimuli compete or are incongruent with one another. Additionally, the role that our social environment plays in how stimuli are integrated and processed has been, until recently, largely understudied. Recent studies have explored the interaction between social and multisensory processes in a visuotactile (Heed, Habets, Sebanz & Knoblich, 2010) and audiovisual spatial congruency task (Wahn, Keshava, Sinnett, Kingstone, & König, 2017), finding that social factors (i.e., performing a task jointly) reduce interference effects. However, these studies have used lower-level stimuli that carry little semantic information (e.g, flashes, vibrations, and beeps). The current study investigates the effect of social factors for more ecologically valid stimuli (spoken and viewed words) in audiovisual and visual versions of a modified Stroop task. In the audiovisual version, bars in four colors (green, red, yellow, and blue) were presented simultaneously with congruent or incongruent spoken color words. In the visual version, the bars were presented with either congruent or incongruent written color words. Participants performed individual or partner conditions. In the individual condition, one participant was required to indicate the color of the bar via button press. In the partner condition, an additional participant was present who was required to indicate whether the stimuli were congruent or incongruent via button press. Relative to the individual condition, we found a reduced interference for incongruent presentations for both versions (visual or audiovisual) of the task in the partner condition. These results extend earlier findings by showing that social factors also affect congruency effects in visual and audiovisual versions of a Stroop task.

Spontaneous head-movements improve sound localization in aging adults with hearing loss

Gessa, Elena[1]; Valzolgher, Chiara[1,2]; Giovanelli, Elena[1]; Spinella, Domenico[3]; Verdelet, Grégoire[2]; Farnè, Alessandro[1,4]; Frau, Giuseppe Nicolò[3]; Pavani, Francesco[1,2]
[1]University of Trento, Rovereto, Italy; [2]Centre de Recherche en Neuroscience de Lyon, France; [3]S. Maria del Carmine Hospital, Rovereto, Italy; [4]Centre de Recherche en Neuroscience de Lyon, France;

Head movements during sound emission can improve sound localization in adults, with or without hearing problems. This effect could result from the possibility to better exploit the available auditory cues when moving the head. It remains to be ascertained if this benefit can also extend to aging adults with presbycusis. Here we compared performance of an asymmetrical hearing-impaired group of elderly participants (range 62-81 years old) with that of a symmetrical hearing-impaired group matched for age. Using motion-tracking in combination with real free-field sounds delivered in a visual virtual reality scenario, we tested participants in a front-back discrimination task and in a 3D sound localization task in the frontal plane. Participants completed the two tasks both with their head static and with head free to move (active listening). In front-back discrimination, the two groups differed and both showed reduced errors in the active listening condition. In 3D sound localization, head movements reduced 3D errors compared to static listening, particularly in the asymmetrical hearing-impaired group. These findings extend to ageing adults with presbycusis the limited literature on the advantage of head-movements on sound localization, and suggest that this benefit may be influenced by the disparity of auditory cues at the two ears. Moreover, this study provides initial evidence that the advantage of active listening persists in ageing and can prove effective even in case of mild hearing loss. These results could be exploited when planning specific interventions in different hearing-impaired population, that could take advantage of self-regulation strategies and active behavior.

Sequential model of audiovisual integration of consonant clusters

Wlaszczyk, Agata[1]; Gil-Carvajal, Juan Camilo[2]; Andersen, Tobias Søren[1]
[1]Danmarks Tekniske Universitet, Denmark; [2]Oticon, Copenhagen, Denmark;

During speech perception, we integrate information from continuous streams of auditory and visual sensory signals and assign it to categorical units (phonemes, syllables, words). The visual information can both increase the understanding of speech in noisy environments and alter the percept if discrepant visual and auditory utterances are presented simultaneously, as demonstrated by the McGurk effect in form of fusion illusions and combination illusions. The fusion illusion, in which two discrepant consonant cues fuse into yet another consonant has been the main focus of the experimental and modeling studies of audio-visual integration in speech perception. These findings, however, do not account for the combination illusion responses that consist of unmodified, incongruent cues from both modalities (e.g. /bg/ response resulting from auditory /g/ and visual /b/). As the characteristics of these two illusions are qualitatively different, there is a need for the theories and models that explain and predict both. The sequential speech cues hypothesis assumes that speech features occurring in the initial segment of an audio-visual utterance are integrated separately from the speech features in the subsequent segment. Here, we test the sequential speech cues hypothesis with an experimental study and computational modelling. We presented audiovisual single consonants and consonant clusters for the phonetically congruent and incongruent audiovisual pairings of utterances (/aga/, /ada/, /aba/, /abga/, /abda/). We found that participants experience novel illusory percepts that suggest that McGurk effect occurred in both initial and subsequent segments of the stimuli. The findings are supplemented with a sequential MLE model that integrates each stimulus segment separately thus emphasizing the temporal aspect of the cues' influence on the final percept. We show that by doing so the model correctly predicts both types of McGurk illusions and produces generalizable predictions, as tested by cross-validation procedure.

A machine learning approach to the crossmodal sound-symbolic word-shape correspondence

Kumar, G. Vinodh[1]; Hoffmann, Ana Maria[4]; Matthews, Kaitlyn L.[4]; Lacey, Simon[1]; Nygaard, Lynne C[4]; Sathian, K.[1,2,3]
[1]Penn State College of Medicine, USA; [2]Penn State Health Milton S. Hershey Medical Center, USA; [3]Penn State College of Liberal Arts, USA; [4]Emory University, Atlanta, USA.;

Sound symbolism refers to non-arbitrary mappings between the sounds of words and their meanings; e.g., auditory pseudowords like "bouba"/"kiki" are perceived as sounding rounded/pointed, respectively. Previously, we reported that perceptual ratings of 537 pseudowords along a rounded-to-pointed scale were significantly correlated with three acoustic (spectral tilt, temporal fast Fourier transform (FFT), speech envelope) and six vocal (harmonics-to-noise ratio (HNR), pulse number, fraction of unvoiced frames (FUF), mean autocorrelation, shimmer, jitter) parameters (Lacey et al., 2020, Cog Sci, 44:e12883). Here, we used machine learning to investigate which combinations of these parameters yielded predicted ratings (of the same set of pseudowords) that best matched the ratings from Lacey et al. (2020: N = 31) and new ratings by different participants (N = 60). We varied the number of parameters from 1-9 and evaluated all possible combinations for a given number, for a total of 511 combinations. Using a k-nearest-neighbors algorithm ($k = \sqrt{537} \approx 23$), for each parameter combination we iteratively computed the Euclidean distance between each pseudoword and the remaining 536 to find its 23 nearest neighbors. The algorithm predicted a rating for each pseudoword based on the modal perceptual rating of its neighbors. We used the Spearman correlation between predicted and actual perceptual ratings to quantify the algorithm's performance. For the N=31 group, the best performance was for a three-parameter model comprising HNR, mean autocorrelation, and shimmer ($r = .54$, $p < 0.0001$). The N=60 group also produced a three-parameter model, sharing two parameters with the N=31 group, comprising HNR, mean autocorrelation, and FUF ($r = .61$, $p < 0.0001$). Thus, pseudoword-shape sound symbolism may rely on patterns of multiple auditory parameters indexing the periodicity and noisiness of pseudoword acoustic form. This approach could be generalized to different pseudowords, different sound-symbolic domains, and to real words.

Tuesday Afternoon Posters

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4:45pm - 5:45pm

Dissociating the involvement of posterior superior temporal region in audio-visual processing through transcranial magnetic stimulation

Ahn, EunSeon; Brang, David
University of Michigan, Ann Arbor, USA;

Speech perception relies on the integration of key multisensory information where the visual lip movement of the speaker can alter the percept of the accompanying acoustic speech. Specifically, this altered perception of what the listener hears by manipulating the visual lip movement of the speaker is known as the McGurk effect. This phenomenon has been widely used to study the audio-visual (AV) integration of speech and used to demonstrate that the information collected by our auditory and visual modalities are combined together in the brain to create a single coherent percept. While prior transcranial magnetic stimulation (TMS) and neuroimaging studies have shown the involvement of the left posterior superior temporal sulcus (pSTS) in facilitating the McGurk effect, there is a limited understanding of the causal link between various dimensions and measures of AV integration and pSTS. For example, recent works suggest that the AV facilitation effect (a measure of benefit gained from AV congruent stimuli compared to audio-only stimuli) and the AV McGurk fusion rate (a measure of how frequently McGurk stimuli are fused), may indeed be measures of separate and distinct AV processing mechanisms. To better understand how these different indices and dimensions of AV integration are causally associated with pSTS, we used continuous theta-burst stimulation (cTBS), a form of repetitive TMS, to disrupt the cortical excitability in this region. Through this stimulation, we will examine the behavioral contributions of pSTS to different AV integration indices such as the McGurk effect, AV facilitation effect, and AV conflict effects with respect to both the accuracy and reaction times to highlight which audio-visual measures, and consequently different AV processing mechanisms, may be modulated by the pSTS.

How early visual deprivation affects the development of the visual cortices of blind humans

Czarnecka, Maria[1]; Hryniewiecka, Katarzyna[1]; Krześniak, Alicja[1]; Dziegiel-Fivet, Gabriela[2]; Plewko, Joanna[3]; Vadlamudi, Jyothirmayi[3]; Jednoróg, Katarzyna[3]; Collignon, Olivier[3]; Szwed, Marcin[1]
[1]Jagiellonian University; [2]Polish Academy of Sciences, Warsaw, Poland; [3]University of Louvain, Belgium;

Cortical reorganization in response to the sensory-deprivation is a well-documented phenomenon, however, there are still many unanswered questions about its mechanism. What are its limiting principles? How does the structural reorganization relate to changes in the brain's function? Here, a group of early blind participants was tested. Participants were instructed to read Braille words and pseudowords during fMRI acquisition. Whole-brain and ROI analyses of the activations in response to the stimuli were conducted and the cortical thickness in six occipital regions of interest was computed. Activation values in the ROIs with their respective thickness estimates were correlated. The results showed task-specific sensory-independent activations evoked by reading Braille in occipital regions. Moreover, an inverse dependency between the activation for semantic contrast and the cortical thickness in the left lingual gyrus was found. Those results suggest that the functional development is associated with thinning of the cerebral cortex.

Selective Adaptation Is Sensitive To The McGurk Effect

Dorsi, Josh[1,2]; Rosenblum, Lawrence D.[2]; Sathian, K.[1]; Zadoorian, Serena[2]; Lacey, Simon[1]
[1]Penn State College of Medicine, USA; [2]UC Riverside, USA;

Selective adaptation is the finding that repetitive exposure to a speech segment (e.g., 'b' in 'ba') will change a perceiver's phonetic criterion for that segment. Selective adaptation is thought to reflect changes to the processing of low-level, sensory information. For McGurk stimuli (e.g., audio 'ba' + video 'va' = perceived 'va'), multiple studies report that adaptation of auditory segments is based on the un-perceived auditory channel, rather than the perceived segments, suggesting that adaptation is insensitive to multisensory information (e.g. Roberts & Summerfield, 1981). However, recent work has reported *crossmodal* adaptation: visual-only speech produces auditory adaptation, and auditory-only speech causes visual adaptation (Dias, 2016). However, no work has yet investigated whether McGurk stimuli might also affect visual adaptation. In Experiment 1 we used a single audio 'ba' + visual 'va' McGurk stimulus as an adaptor for two groups of participants: one group identified stimuli from an auditory-only continuum; the other identified stimuli from a *visual-only* continuum. The McGurk stimulus produced 'ba' adaptation on the auditory continuum, but 'va' adaptation on the visual continuum. This indicates that the auditory and visual streams of the McGurk stimulus produce concurrent contrasting adaptation effects. We next investigated if these contrasting auditory and visual adaptation effects might dilute adaptation in the opposite modality related to competing within and cross-modal influences. A meta-analysis of published studies found that McGurk adaptors, relative to audio-only adaptors, produce a small but consistent reduction in the size of the auditory adaptation effect. This result challenges the assumption that selective adaptation is insensitive to multisensory information; it seems that McGurk stimuli may produce competing within and cross-modality adaptation effects. Experiment 2 will build on these findings, investigating if the McGurk reduction of the adaptation effect is based simply on the cross-modal adaptation produced by the visual component on the auditory continuum.

The McGurk effect: A linguistic view of a multisensory speech illusion.

Liapi, Lydia Kalliopi; Vatakis, Argiro
Panteion University of Social and Political Sciences, Greece;

The McGurk effect is a well-known illusory demonstration of multisensory integration, where, for example, a visual /ga/ combined with an auditory /ba/ leads to the illusory fused percept of /da/, /ta/, or /θa/, while a visual /ba/ combined with an auditory /ga/ leads to the combined percept of /bga/. However, it is not clear from the current literature how the illusion works with other syllable combinations and in speakers of other languages. In the present study, therefore, we investigated the McGurk effect in native speakers of the Greek language by presenting congruent and incongruent combinations of the syllables /ba/-/ga/, /θa/-/va/ and the disyllables /ðiki/-/fiki/, /ðiki/-/miki/. Participants reported via multiple-choice their percept for each stimulus presented. Other than the classic version of the McGurk effect (i.e., visual /ga/-auditory /ba/ combinations), which did not induce a McGurk percept in native Greek speakers, all other stimulus combinations examined led to surprisingly high rates of fused and low rates of combination responses. These findings suggest that the native language's phoneme characteristics may affect how people experience the McGurk illusion. We, thus, analysed our findings in terms of place and manner of articulation of the presented audiovisual combinations and the perceived fused responses. We found that the fused percept always had the same place of articulation as the visual component and mostly -but not always- the same manner of articulation of the corresponding auditory component of the presented stimulus. These findings suggest that the McGurk effect is affected by linguistic factors and combinations inducing this illusion may differ between languages. We are currently conducting follow up studies utilizing a wider set of syllables, with native speakers of Greek, as well as other languages, aiming to examine how manner and place of articulation define the fused or combined percept of incongruent audiovisual speech combinations.

Unmasking the difficulties of listening to talkers with masks: lessons from COVID19 pandemic

Giovanelli, Elena[1]; Valzolgher, Chiara[1,2]; Gessa, Elena[1]; Todeschini, Michela[1]; Pavani, Francesco[1,2]
[1]University of Trento, Rovereto, Italy; [2]Centre de Recherche en Neuroscience de Lyon, France;

Interactions with talkers wearing face masks have become daily routine since the beginning of COVID-19 pandemics. We recently examined the visual impact of face masks on speech understanding. Typical-hearing listeners performed a speech-in-noise task while seeing talkers with visible lips, talkers wearing a surgical mask or written talkers' name only. The target voice was masked by concurrent distracting talkers. We measured performance, confidence and listening effort scores, as well as meta-cognitive monitoring (i.e. the ability to adapt self-judgments to actual performance). Results showed that hiding the talkers behind a screen or concealing their lips via a face mask, led to lower performance and lower confidence scores, as well as increased perceived effort. These findings have implications on everyday communication for typical-hearing individuals and, particularly, for hearing-impaired populations. Moreover, meta-cognitive monitoring was worse when listening in the masked condition compared to listening to an unmasked talker or to someone we cannot see. This has potential consequences on the willingness to play out behavioral strategies to overcome these understanding obstacles, most likely impacting on the feeling of unsureness of what is heard. In turn, this could lead to a listening frustration that can cause social isolation and risky behaviors like diminishing interpersonal distancing or taking off the face mask.

The role of ageing on self-reported ability across multiple senses: a longitudinal analysis. (moved to Talk Session: Wed. 10:15am)

O'Dowd, Alan M[1]; Hirst, Rebecca J[1]; Setti, Annalisa[1,2]; Kenny, Rose Anne[1,3]; Newell, Fiona N[1]
[1]Trinity College Dublin, Ireland; [2]University College Cork, Ireland; [3]St. James Hospital, Dublin, Ireland;

During the healthy ageing process, sensory degeneration typically occurs and often in more than one sensory modality. This can present significant challenges to the well-being and quality of life of older adults. Here, we used discrete survival analysis to explore the longitudinal (10 year) associations between demographics, lifestyle factors and measures of sensory-, physical- mental- and cognitive health and the hazard of transitioning from normal to impaired sensory function for vision, audition, olfaction and gustation. Sensory impairment was captured with self-report measures for a large sample of older adults (N = 4,831), drawn from The Irish Longitudinal Study on Ageing. Auditory impairment was most prevalent, followed by impaired vision, olfaction and gustation. Multivariable regression models revealed an increased probability of impairment in one modality for those reporting impairments in other modalities. Vision impairment was associated with socioeconomic status, eye disease and depression. Auditory impairment was associated with age, sex of participant, education and hearing aid use. Olfactory impairment was associated with age, sex of participant and smoking. Gustatory impairment was associated with age, smoking and depression. Self-rated impaired health was associated with an increased probability of impairment for all modalities. Our results suggest that older adults generalise perceived impairment across multiple senses over time, but at different rates. Also, sensory decline is associated with both global and modality-specific factors, thereby furthering our understanding of the impact of sensory health in ageing.

Tuesday Afternoon Posters

Tuesday Afternoon Posters

4:45pm - 5:45pm

Increase of the audio-visual spatial integration window with age but not hearing loss

Huisman, Thirsa[1,2]; MacDonald, Ewen N[1,4]; Piechowiak, Tobias[3]; Dau, Torsten[1]
[1]Technical University of Denmark, Denmark; [2]Johannes Gutenberg University Mainz, Germany; [3]GN Hearing, GN ReSound, Denmark; [4]University of Waterloo,;

Audio and visual information can be integrated over a range of spatial stimulus disparities, i.e., the spatial integration window. To investigate how age and hearing loss influence this spatial integration window, the present study examined the spatial window of audio-visual integration in eight young normal-hearing, six older normal-hearing and seven older hearing-impaired participants. The just-noticeable difference (JND) in angle was measured for each participant in audio-only, visual-only, congruent audio-visual and incongruent audio-visual conditions and at five azimuthal angles (±30°, ±15° and 0°), using a left-right discrimination task. In the incongruent audio-visual condition, the visual stimulus was always halfway in between the auditory stimuli, to ensure that participants could not rely on visual information to perform the task. On repeated successful trials, the spatial distance was decreased, increasing the probability of integration and highly increasing the difficulty of the task. When the distance between the auditory stimuli was large enough, such that the auditory stimuli were no longer integrated with the visual stimuli, listener judgment was assumed to be based on audio-only processing. Hence, an increase in the JND in the incongruent condition, compared to the audio-only condition, was considered to relate to width of the spatial integration window. With this method the effect of a hearing-loss and age on the spatial integration window was assessed.

Older adults with a history of falling exhibit altered cortical oscillatory mechanisms during continuous postural maintenance

Jiang, Fang; Scurry, Alexandra; Szekely, Brian; Murray, Nicholas
UNR, United States of America;

The significant risk of falling in older adults 65 years or older presents a substantial problem for these individuals, their caretakers, and the healthcare system at large. As the proportion of older adults in the United States is only expected to grow over the next few decades, a better understanding of physiological and cortical changes that make an older adult more susceptible to a fall is crucial. Prior studies have displayed differences in postural dynamics and stability in older adults with a fall history (FH) and those that have never fallen (NF), suggesting surplus alterations that occur in some older adults (i.e. FH group) in addition to the natural aging process. The present study measured postural dynamics while FH, NF and young adult (YA) groups performed continuous postural maintenance. In addition, EEG activity was recorded while participants performed upright postural stance to examine any group differences in cortical areas involved in postural control. As expected, FH participants exhibited worse postural stability, as evidenced by increased excursion, compared to NF and YA groups. Further, while NF and YA show increased alpha activity in occipital areas during the most demanding postural task (eyes closed), FH group did not show any differences in occipital alpha power between postural tasks. As alpha activity reflects suppression of bottom-up processing and thus diversion of cognitive resources toward postural centers during more demanding postural maintenance, deficits in this regulatory function in FH group is a possible impaired cortical mechanism putting these individuals at greater fall risk.

[withdrawn] The feeling of “kiki”: select tactile exposure or visual imagery can enhance abstract audio-tactile crossmodal correspondences, the bouba-kiki effect, early in development

Ciaramitaro, Vivian; Kelly, Julia; Nguyen, Cuong
University of Massachusetts, United States of America;

The bouba/kiki effect is a naturally occurring association between abstract shapes, spikey or round, and nonsense words, /kiki/ or /baba/, respectively, found across cultures, languages, and different senses (reviewed in Spence, 2011). Previously, we found developmental changes: compared to adults, 6-8 year-old children showed weaker audio-tactile (AT) associations between heard nonsense sounds and felt abstract shapes, even when provided with explicit instruction on how to optimally explore shapes via touch or given twice as many trials of exposure (Chow et al., in revision). Interestingly, AT associations could be strengthened if participants had to first match the same non-sense sound to complementary seen abstract shapes (audio-visual) or the same felt shape to complementary seen shapes (visuo-tactile). Given that both audio-visual and visuo-tactile conditions provide prior visual exposure to shapes, and that early-blind-adults (Fryer et al., 2014) show abnormal AT associations, we considered if visual experience is critical or if what matters is that relevant shape features are highlighted, something more automatic in vision than touch. Here we tested if prior tactile-only (TT) exposure could enhance AT associations in a task highlighting relevant shape features without providing visual exposure and if prior imagery of abstract shapes (IT) could enhance AT associations. In TT, children had to first match a smaller shape to one of two larger shapes. Shapes only differed in 2D contour, not texture or material properties, and were felt, but, not seen. In IT, children had to first imagine which shape, a cloud or star, matched a felt shape. We found that TT exposure which highlights important shape features enhanced AT associations in children, suggesting that visual experience may be sufficient, but not necessary, in forming the abstract AT associations tested here. Visual imagery, also enhanced AT associations, further suggesting direct visual experience of abstract shapes is not necessary.

Multi-modal object fusion in superior colliculus - a complete neuromorphic model

Schmid, Daniel[1]; Oess, Timo[2]; Neumann, Heiko[1]
[1]Institute of Neural Information Processing, Ulm University, Germany; [2]Bernstein Centre Freiburg, University of Freiburg;

Problem. Reliable tracking of objects benefits from fusing multiple sources of sensory evidence, such as visual and auditory information. Functionally, such fusion reduces the uncertainty of signal processing. A subcortical site of early sensory integration is the superior colliculus (SC) where visual and auditory inputs interact within a topographically aligned representation (Meredith & Stein, *J Neurophys*, 1996). Topographic positions receiving coinciding input from both modalities are found to be enhanced by coinciding top-down signals from cortical representations (Alvarado et al., *J Neurosci*, 2007) leading to the property of inverse effectiveness of multisensory neurons (Stein & Stanford, *Nat Rev Neurosci*, 2008). *Method.* Here, we present how a model of multisensory integration in SC behaves for real-world input. The model is based on previous investigations of our group (Oess et al., *Front Neurorobot*, 2020) and receives visual input from a neuromorphic camera and auditory input from an open-source dataset of real-world sounds. Both inputs are pre-processed yielding topographic representations of amplitude responses as functions of retinal input and sound frequency. Our model utilizes spiking neurons and incorporates cortical feedback to register visuo-auditory coincidence. Spatial fusion of multi-modal real-world objects and its dependency on the model parameters are investigated. We demonstrate how systematically varying the visual object's angular position relative to sound source position influences SC responses when cortical top-down feedback is present or absent, respectively. *Results and Conclusion.* The model is capable of integrating stimuli within a range of spatial offsets between uni-modal inputs in accordance with the spatial principle of multisensory integration. The supported range of offsets leading to stimulus fusion depends on the spatial extent of the connection weights and the availability of coinciding cortical feedback. Simulation results demonstrate the model's ability to successfully integrate real-world visuo-auditory stimuli controlled by cortical feedback enabling response enhancement, thus enhanced object detection capabilities.

Visuo-haptically guided grasping in cataract-treated children

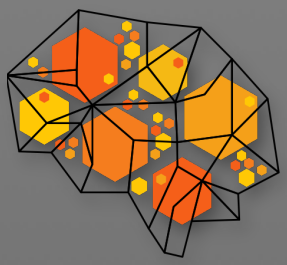
Piller, Sophia[1]; Senna, Irene[1]; Wiebusch, Dennis[1]; Volcic, Robert[2]; Ernst, Marc O.[1]
[1]Ulm University, Germany; [2]New York University Abu Dhabi, United Arab Emirates;

Skillful grasping movements can be performed towards objects sensed visually, haptically, or visuo-haptically. Typically, reliability of the available sensory information influences the performance, with the most cautious grasps performed in presence of solely haptic information, the most accurate and precise ones when visual and haptic information is integrated (i.e., when grasping with one hand objects held with the other), and a performance in-between when only visual information is available. Would a person that had haptic but only very limited visual experience so far be able to successfully perform visually guided grasps and benefit from multisensory integration when grasping handheld objects? We investigated a sample of cataract-treated patients (i.e., born with dense bilateral cataracts, and surgically treated years after birth), and compared their grasping performance after cataract removal with that of an age-matched group of typically developing children. Participants reached for and grasped an object with their dominant hand in three conditions: In the haptic condition participants were blindfolded but allowed to touch the object with their non-dominant hand to haptically sense its size and position while grasping it. In the visual condition, participants were allowed full sight, but no object contact prior to the grasp. In the visuo-haptic condition participants had full vision and additionally touched the object with their non-dominant hand while grasping it with the other hand. While sighted controls behaved as expected (VH>V>H), cataract-treated patients showed the least efficient grasping behavior when only visual information was available, reflected by the longest grasp duration, largest maximum grip aperture and lowest movement velocity among the three conditions. However, similar to controls, they performed best in the visuo-haptic condition (i.e. VH>H>V). The results suggest that early and prolonged visual deprivation harms the development of skillful visually guided grasping, but does not prevent the integration of visual and haptic sensory information.

Modulation of phonetic perception by invisible lip movements

Teramoto, Wataru[1]; Ernst, Marc O.[2]
[1]Kumamoto University, Japan; [2]Ulm University, Germany;

It is well known that visual information from lip movements affects phonetic perception (e.g., the McGurk effect). Nevertheless, recent studies have reported that the visual modulation on phonetic perception does not occur without awareness of visual stimuli. In this study, we investigated this issue using continuous flash suppression (CFS) and the McGurk aftereffect, a phenomenon in which the experience of the McGurk illusion modulates subsequent auditory perception (Bertelson, Vroomen, & de Gelder, 2003). In two experiments, after exposure to McGurk stimuli (auditory /ba/ with visual /ga/), an auditory /ba/ was presented in conjunction with either a visual /ba/ (congruent), visual /da/ (incongruent), or stationary lip image (baseline) to the non-dominant eye, which was masked by dynamic CFS stimuli to the other eye. Participants were asked to report which syllables they heard (/ba/, /da/, or /ga/) and whether they saw the lip movements or image. We predicted that the McGurk aftereffect should equally occur across the visual conditions if invisible lip information were not involved in auditory perception. Results showed that the McGurk aftereffect (i.e., /ga/ or /da/ responses) less frequently occurred in the congruent condition than in the other conditions (Experiment 1). The time course data showed that the McGurk aftereffect quickly diminished in the congruent condition while it prolonged in the other conditions (Experiment 2). These results suggest that visual signals at a relatively early level (at least prior to perceptual awareness) can interact with auditory perception at the level of encoding syllables.



IMRF

International Multisensory Research Forum

ULM 2022

Wednesday Morning Talks

Wednesday Talks

8:30am - 9:15am

Room Danube

Multisensory Concepts

8:30am - 8:45am

Three metacognitive challenges to multisensory research

DEROY, Ophelia
LMU, Germany;

Humans can monitor how reliable their perceptual decisions are, given certain evidence: they assign degrees of confidence, or invest different amounts of time in acting on these perceptions. This metacognitive capacity is heavily investigated using visual tasks, and needs to be also in multi sensory cases. This talk highlights why multisensory cases raise specific challenges, by contrast with the unisensory ones. It examines some key expectations that derive from studies of both metacognition and multi sensory interactions, and illustrate the challenges with recent results, including 3 of our own. 1. There are perfect multisensory metamers: Many famous multi sensory illusions, such as the McGurk cases or the flash-beeps illusions, suggest that integrated percepts resulting from conflicting or non-conflicting cues are subjectively indiscriminable. However, new results show that participants do feel less confident in the percepts that result from integrating conflicting cues. 2. Weighing of cues is unconscious: When we touch and see an object at the same time, the information coming from touch and vision are weighted according to their reliability, estimated through the precision of each signal. Priors regarding the reliability of each modality for the task may also play a role. Both kinds of reliability are said to be estimated automatically, without participants' awareness or control. Our studies suggest here that changes in the awareness about the reliability of a given cue affects the resulting integration. 3. Confidence is a common-currency across the senses: Crossmodal checking occurs when participants revise a perceptual estimate in one modality, based on a second check of the same object in a second modality (for instance, estimating the length of an object by vision, then checking it by touch). The third studies mentioned in the talk will show why differences in. biases in metacognitive assessments make this combination problematic.

8:45am - 9:00am

Seeing Music: leveraging citizen science and gamification to study cross-sensory associations

Saitis, Charalampos[1]; Cuskley, Christine[2]; Löbbers, Sebastian[1]
[1]Centre for Digital Music, Queen Mary University of London, United Kingdom; [2]Linguistics and Centre for Behaviour and Evolution, Newcastle University, UK;

Our recent research (https://psyarxiv.com/ghcxv/) has shown that people lack knowledge about how the senses interact and are unaware of many common forms of sensory and perceptual variation. We present Seeing Music (https://seeingmusic.app/), a digital interactive exhibition and audiovisual game that translates high-level scientific understanding of sensory variation and cross-modality into knowledge for the public. Using a narrative-driven gamified approach, players are tasked with communicating human music to an extraterrestrial intelligence through visual shape, color and texture using two-dimensional selector panels. Music snippets (12–24 s long) are played continuously in a loop, taken from three custom instrumental compositions designed to vary systematically in terms of timbre, melody, and rhythm. Players can "level-up" to unlock new visual features and musical snippets, and explore and evaluate collaborative visualizations made by others. Outside the game, a series of interactive slideshows help visitors learn more about sensory experience, sensory diversity, and how our senses make us human. The exhibition debuted at the 2021 Edinburgh Science Festival, where it was visited by 197 users coming from 21 countries (134 visitors from the UK) over 16 days. As it continues running online, a further 596 visitors from 35 countries (164 from the UK) have engaged. To date, 169 players of Seeing Music have produced more than 42,500 audiovisual mapping datapoints for scientific research purposes. Preliminary analysis suggests that music with less high-frequency energy was mapped to less complex and rounder shapes, bluer and less bright hues, and less dense textures. These trends confirm auditory-visual correspondences previously reported in more controlled laboratory studies, while also offering new insight into how different auditory-visual associations interact with each other. Future work includes improving user motivation and interaction, refining data collection, a full open-source release, and adding new games and informational material about research on the senses.

9:00am - 9:15am

Body models in humans, animals, and robots: mechanisms and plasticity

Hoffmann, Matej
Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic;

Humans and animals excel in combining information from multiple sensory modalities, controlling their complex bodies, adapting to growth, failures, or using tools. These capabilities are also highly desirable in robots. They are displayed by machines to some extent—yet, as is so often the case, the artificial creatures are lagging behind. The key foundation is an internal representation of the body that the agent—human, animal, or robot—has developed. In the biological realm, evidence has been accumulated by diverse disciplines giving rise to the concepts of body image, body schema, and others. In robotics, a model of the robot is an indispensable component that enables to control the machine. In this article I compare the character of body representations in biology with their robotic counterparts and relate that to the differences in performance that we observe. I put forth a number of axes regarding the nature of such body models: fixed vs. plastic, amodal vs. modal, explicit vs. implicit, serial vs. parallel, modular vs. holistic, and centralized vs. distributed. An interesting trend emerges: on many of the axes, there is a sequence from robot body models, over body image, body schema, to the body representation in lower animals like the octopus. In some sense, robots have a lot in common with Ian Waterman—"the man who lost his body"—in that they rely on an explicit, veridical body model (body image taken to the extreme) and lack any implicit, multimodal representation (like the body schema) of their bodies. I will then detail how robots can inform the biological sciences dealing with body representations and finally, I will study which of the features of the "body in the brain" should be transferred to robots, giving rise to more adaptive and resilient, self-calibrating machines.

Spotlight Talk

9:15am - 9:45am

Pretty Ugly: Why we like some songs, faces, foods, plays, pictures, poems, etc., and dislike others

Maurer, Daphne. McMaster University, Canada;

Abstract. Homo sapiens are aesthetic beasts. People have decorated their environments since palaeolithic times. This talk will draw on experimental evidence from human development to explain how such aesthetic preferences are formed, and will show how the same principles apply across sensory modalities. Their origin appears to lie in how the multi-sensory environment interacts with the structure of the nervous system. A baby's structural biases and limitations constrain attention, making some stimuli easier to process and some of those particularly salient. From these structures and limitations, the mechanism of aesthetic preferences emerges. This is a consilient approach to aesthetics. In this short talk I shall illustrate it for taste preferences, judgments of facial beauty, music and dance. The talk will draw on my 50 years of laboratory research on the development of perception plus 30 years of library and field research that went into my recent book, published with Charles Maurer, Pretty Ugly. http://prettyugly.info/

Bio: Daphne Maurer is a Distinguished University Professor from the Department of Psychology, Neuroscience and Behaviour at McMaster University in Canada. She has over 200 publications and she is a Fellow of the Royal Society of Canada.

Wednesday Morning Talks

Wednesday Talks

10:15am - 11:15am

Room Danube

Chemical & Pain

10:15am - 10:30am

The impact of proprioception and visual experience on nociception and pain

Legrain, Valéry
Université catholique de Louvain, Belgium;

The nociceptive system is the physiological system by which the brain processes and reacts to stimuli that have the potential to inflict damage upon the body and which are generally perceived as painful. Efficiently reacting to physical threats requires to locate adequately pain on the body but also to locate the stimulus that caused the pain in the space surrounding the body. This is made possible by interactions between nociceptive and extra-somatic (e.g. visual) stimuli according to a multisensory spatial representation of the body and its immediate surroundings, namely the peripersonal space. However, such multisensory interaction between nociceptive and extra-somatic stimuli represent a challenge for the brain, as sensory inputs from each modality are initially encoded into modality-specific reference frames, such as the somatotopic reference frame for nociception. Here we will provide arguments showing that, as largely demonstrated for touch, nociceptive stimuli are also remapped into a spatiotopic reference frame, not only taking into account which body part is in pain, but also where the painful limb is in external space. It was indeed shown that changing the posture of the limbs affects the temporal order judgements of nociceptive stimuli but also the intensity of the pain triggered by these stimuli. Moreover, it has also been evidenced that people with early visual deprivation do not react to nociceptive stimuli as normally sighted people. These data strongly suggest that processing nociceptive stimuli and experiencing pain depends on multisensory integration with proprioceptive and visual feedbacks.

10:30am - 10:45am

Multisensory interactions underlying flavor preference decisions: the role of experience

Maier, Joost X; Garrison, Megan N
Wake Forest School of Medicine, United States of America;

Flavor is a major determinant of consumption behavior. Although commonly referred to as “taste”, flavor is a quintessential multisensory experience: drawing from gustatory, olfactory and somatosensory inputs, each sourced from separate peripheral senses. Previous work in humans demonstrate that multisensory flavor cues are integrated to inform certain perceptual decisions. However, given the lack of experimental control over eating experience, the computations underlying multisensory flavor interactions and their role in food choice behavior remain poorly understood. Here, we overcome these limitations by using rats as a model system. In Experiment 1, we asked how rats raised on a controlled diet of lab chow use taste and smell components of flavor solutions to inform consumption behavior. In a series of daily two-alternative free choice tests, rats drank freely from two bottles containing taste+odor mixture solutions (test and control). Taste and odor components in the test solution varied across days from palatable to unpalatable, relative to a neutral control solution. Amount consumed was used to calculate relative preference for test solutions. Multisensory mixture preferences could be explained by a weighted average of the unisensory component preferences. Although the weight placed on the taste component was overall stronger than the weight placed on the odor component, weight on odor increased with decreasing reliability of the taste component. In Experiment 2, we then asked whether weight on odor components may be influenced by experience. We performed identical tests on a second group of animals that were raised on a diet consisting of a wide variety of real foods, enriching their flavor experience. Rats raised on a real food diet placed a greater weight on odor components of flavor solutions compared to chow-raised animals. This work provides a theoretical framework for understanding the multisensory interactions underlying hedonic evaluation of flavor and the factors that shape them.

10:45am - 11:00am

Odour with Trigeminal Properties Ventriloquized Sound

Liang, Kun; Chen, Lihan
Peking University, China, People's Republic of;

Olfaction, as an ancient sense, assists both humans and animals in localization and navigation. We explored the emerging role of unilateral odour influx in the context of human sound localization. Participants were examined on a sound localization task under the condition of selective unilateral odour influx. Three odour stimuli were involved, 10% v/v phenylethyl alcohol as pure olfactory stimulus, 1% v/v menthol as mixed olfactory/trigeminal stimulus, and propylene glycol as the control. Sounds with different azimuths (0°, 5°, 10°, and 20° unilaterally deflected from the sagittal plane) were generated by the head-related transfer function (HRTF). Participants were required to judge the sound localization (leftward or rightward) and confidence level of the judgements during inhalation. No statistical evidence proved that unilateral PEA influx influenced human sound direction judgements. However, unilateral menthol influx led to a systematic bias in perceived sound direction, shifting towards the odour side. This odour-specific sound bias effect was independent of gender. The difference limen of sound localization was not significant among five odour-nostril conditions. Results suggested that unilateral odour influx could bias perceived sound direction only when the odour activates the trigeminal nerve. This odour-induced sound bias was not gender-specific.

11:00am - 11:15am

Olfactory crossmodal correspondences are partly explained by the physicochemical features of odours

Ward, Ryan Joseph[1]; Wuerger, Sophie[2]; Marshall, Alan[1]
[1]Department of Electrical Engineering & Electronics, University of Liverpool, United Kingdom; [2]Department of Psychology, University of Liverpool, UK;

The relationship between the perception of odours and their physical and chemical (physicochemical) features remains unclear. The chemical features of odours are presumed to be recognised during the olfactory perception process, if this hypothesis holds true then both the physical and chemical attributes of an odour could partially contribute towards explaining our crossmodal perception. An artificial construct of the human olfactory system is called an electronic nose; these noses consist of an array of semi-selective gas sensors that can detect and record the physicochemical features of odours. Crossmodal correspondences are the non-arbitrary but consistent associations that occur between different stimulus features in different sensory modalities, such as those between the smell of peppermint to being associated with a higher pitch. We explored the role the underlying physicochemical features play in explaining olfactory crossmodal correspondences, namely between ten odours and the angularity of shapes, smoothness of texture, perceived pleasantness, pitch, and colours. We found that all of our crossmodal perceptual dimensions are highly correlated with the aspects of intensity and odour quality (all p-values < 0.001). We also found that a predictable and systematic link exists between the physicochemical features of odours and olfactory crossmodal correspondences and between 6% - 23% of variance was explained by the physicochemical features (all p-values less than a Bonferroni corrected alpha of 0.0071). Consequently, suggesting that the presence of specific volatile organic compounds and the physical characteristics (i.e., humidity) of odours play a minor role in explaining our crossmodal perception. This link between the physicochemical features and crossmodal correspondences may be explained by complexity / intracity, odour quality and/or intensity.

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Can impersonal touch replace interpersonal touch? An investigation using the rubber hand illusion

Bae, Jaehyoung; Wallraven, Christian
Korea University, Seoul, South Korea;;

Our socio-emotional development and well-being critically depends on interpersonal tactile interactions, which are sensed by the skin through C-tactile (CT) afferents that respond to gentle, slow touch at typical skin temperatures. In the present study, we investigated whether impersonal touch would be able to provide similar pleasantness compared to interpersonal touch within a body ownership illusion paradigm. To provide impersonal touch at similar parameters, we used a thermal probe kept at 32°C (typical skin-to-skin temperature) and compared to a flat hand as interpersonal touch. Both forms of touch were performed at CT-compatible speeds of 3cm/s by a trained experimenter within a classic rubber hand illusion (RHI) paradigm in two counter-balanced within-participant conditions: in the interpersonal condition, the experimenter performed the stroking with a flat hand on the right (hidden) forearm, whereas in the impersonal condition, participants were stroked with the probe. In both conditions, participants watched the hand of the experimenter stroking the rubber hand. A sample of 45 healthy participants (23 women, mean age 23.8 years, sample-size determined beforehand) were tested and pleasantness ratings, RHI ratings, and the Need-For-Touch-Scale (NFT) were gathered. Overall, the illusion was similar in both conditions (t=0.0, p=1.0, mean=0.0, std=1.365), and importantly, we found no statistically significant difference in pleasantness between interpersonal and impersonal touch (t=0.479, p=.634, mean=0.111, std=1.555). None of the NFT scores were able to predict pleasantness in either condition (all p>.05). Excepting visual top-down influences from the human hand that was seen stroking, we confirm that impersonal touch from our probe is enough to induce the body ownership illusion, and that our stimulation parameters provide a hedonic experience comparable to human touch - impersonal touch may therefore be able to replace interpersonal touch.

Contributions of Body Ownership to Memory Accuracy and Phenomenology

Iriye, Heather Miyoko; Ehrsson, H. Henrik
Karolinska Institutet, Sweden;

Our bodies provide a necessary scaffold for memories of past events. Yet, we are just beginning to understand how fundamental feelings of one's own body during the encoding of realistic events shape memory accuracy and phenomenology. Here, participants formed memories for immersive, lifelike events by watching pre-recorded 3D videos that involved a first-person view of a mannequin's body through head mounted displays. We manipulated feelings of body ownership over the mannequin using a perceptual full-body illusion. Participants saw an object touch the mannequin and simultaneously felt touches on the corresponding location of their real body, which created an illusory sense of ownership over the mannequin. As a control condition, we disrupted the illusion by delivering seen and felt touches in an alternating pattern in half of the videos. Participants completed cued recall questions pertaining to event details and subjective ratings (i.e. degree of reliving, emotional intensity, vividness, and belief in memory accuracy) for each video immediately following encoding and one week later. Repeated-measures ANOVAs show that sensing the mannequin's body as one's own during encoding enhanced cued recall accuracy at both testing points, reliving at immediate testing, and emotional intensity, vividness, and belief in memory accuracy at delayed retrieval, compared to the disembodied control condition. These findings suggest that a basic sense of bodily selfhood provides a crucial foundation for the accurate and vivid reliving of the personal past.

Referral of sensation via mirror reflection – effect, best techniques and nature of responders – a mixed-methods within-person cross-over study

Hagenberg, Annegret[1,2]; Maltby, John[1]; Gillies, Clare[1]; Jussab, Shifa[3]; Lambert, Dave[1]; Robinson, Thompson[1]
[1]University of Leicester, UK; [2]Hochschule Fresenius, DE; [3]Leicestershire Partnership Trust, UK;

This study aimed to investigate how the use of touch in a mirror therapy setting can modulate the sensory system. Referral of sensation (RS) had been described in the literature, with larger effects of RS when using a rubber hand, but the development of effects in relation to touch and pressure techniques and the nature of responders were unclear. A mixed-methods, within-person crossover study was conducted with follow-up within three weeks. Participants' hands, feet as well as rubber hands (male or female respectively) and rubber feet were stimulated in a mirror setting, using brushes and touch, randomised by order of testing. Experiment and interview were audio-recorded and triangulated with psychological questionnaires. In 47 healthy participants (22 male) of mean age 51.6 years (range 20 to 83), RS was experienced by 76.6% on at least two occasions over eight cycles of stimulation, could often be individually modulated, and was mostly well accepted. Some participants experienced elicited numbness. There was a significant association of response with extraversion (p=0.040) and openness to experience (p=0.031). This study has shown the nature of RS, sensory perception, and psychological factors relevant for response. The possibility to modulate sensory perception opens up new options in rehabilitation. The question remains whether the brain will default towards health, i.e. reducing numbness and hypersensitivity respectively.

Dissociations and interactions between illusory part- and full-body ownership

O'Kane, Sophie Helena; Ehrsson, H. Henrik
Karolinska Institutet, Sweden;

In the full-body ownership illusion, healthy participants experience illusory feelings of ownership for a mannequin's entire body following synchronous visuotactile stimulation. However, experimental conditions have previously generated either illusory body-part and full-body ownership or neither percept, leaving open questions regarding dissociations and interactions between part and whole in body ownership perception. We investigated how combinations of synchronous and asynchronous visuotactile stimulation affect illusory body part and full-body ownership. In Experiment 1 (N=48), eight experimental conditions comprised all possible configurations of synchronous and asynchronous stimulation across the right arm, the trunk, and the right leg ($S/A_{RA}S/A_TS/A_{RL}$). Cumulative link mixed effects modelling and pair-wise tests revealed a non-linear relationship between the number of synchronously stimulated body parts and illusory full-body ownership ratings: while increasing the number from 1-2 (p = .003) and 2-3 (p < .001) was predictive of significant increases in illusory full-body ownership, no significant differences occurred between 0-1 (p = .232). There were no significant differences in illusory full-body ownership due to which of the three body parts received synchronous or asynchronous stimulation. In Experiment 2 (N=48), we demonstrated that mixed synchronicity stimulation produces a dissociation between illusory part- and full-body ownership (pooled analysis; all $p_{FDR} \leq .01$ where hypothesised). In Experiment 3 (N=48), skin conductance responses (SCRs) for threats targeting the mannequin's right arm were recorded, as participants experienced identical conditions to Experiment 2. We found significantly reduced threat-evoked SCRs for all conditions relative to fully synchronous (all $p_{FDR} < .05$), highlighting the importance of integrating an illusorily owned body part into a coherent illusory full-body ownership percept for threat-evoked SCRs. Findings suggest that it is possible to isolate and unify subjective experiences of illusory body-part and full-body ownership with combinations of synchronous and asynchronous visuotactile stimulation, supporting the fundamental role of multisensory integration in body ownership perception.

Enhanced cardiac interoceptive accuracy is related to cortical thickness of the occipital cortex in congenitally blind individuals

Stroh, Anna-Lena[1]; Radziun, Dominika[2]; Korczyk, Maksymilian[1]; Ehrsson, Henrik[2]; Szwed, Marcin[1]
[1]Jagiellonian University, Poland; [2]Karolinska Institutet;

It has been shown that blindness leads to specific behavioral enhancements in several domains, such as language, sound localization, and certain body-related functions. Radziun et al. (in preparation) have recently observed that congenitally blind individuals have significantly higher cardiac interoceptive accuracy as compared to sighted individuals. It could be hypothesized that these behavioral enhancements are due to structural changes within the deprived cortices. Indeed, previous studies have demonstrated that congenitally blind individuals show increased cortical thickness within occipital areas compared to sighted individuals. How these structural changes relate to behavioral enhancements is less clear. To address this issue, we assessed cardiac interoceptive abilities using the heartbeat counting task and cortical thickness in 18 congenitally blind individuals. Preliminary analyses revealed correlations between performance on the heartbeat counting task and cortical thickness within occipital regions. These findings suggest that structural changes within occipital areas are related to enhancements in blind individuals' ability to perceive their heartbeats.

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Rethinking Reality through Unreality

Cho, Youngil
Fukui University of Technology, Japan;

The constant improvements of high-performance graphical and display technologies have allowed us to rethink reality. Virtual reality allows people to expand the sense of presence not only in physical reality but also a reality beyond it called unreality. It is a common and traditional conception in spatial perception research works to assume that vision is the primary sense that gives a variety of cues regarding the elements in a scene and can trigger various behaviors such as reaching, grasping, and arranging. However, what if visual element of our body is absent in spatial perception? How will the loss of this sensory information affect cognitions in the virtual space? What are the differences in behavior caused by mono-modality (visual or tactile) and multi-modality (visual-tactile) in spatial perception? The present research gives an insight into the role of embodied cognition, the ability to recognize an object's physical location as well as the physical relationships between objects with focus on visual-spatial perception. In the experiment, the participants grab or move a ball in the virtual space with or without a virtual hand as a visual stimulant. The findings from the results provide an insight into the meaning of embodied cognition as part of visual information on the sense of presence and research practices with focus on the presence or absence of other senses on experience while keeping vision as default in virtual reality.

Sound Congruence and the Rubber Hand Illusion

Coppi, Sara; Ehrsson, H.Henrik
Karolinska Institute, Stockholm, Sweden;

Multisensory integration of bodily signals has been studied by rubber hand illusion. In this illusion synchronous stroking of a rubber hand, in full view, and a person's real hand, which is hidden from view, leads to the perceptual fusion of vision and somatosensation and the feeling of the model hand as one's own. However, little is known about how sounds influence the rubber hand illusion and multisensory body perception. To address this issue, we manipulated the congruency of the sound with respect to the material-tactile properties objects touching the rubber hand and real hand in rubber hand illusion paradigm. The rubber hand illusion was quantified behaviorally as the degree of shift in hand position sense towards the rubber hand ("proprioceptive drift"), and subjectively by questionnaire ratings. In the first experiment, we observed significantly greater proprioceptive drift toward the rubber hand after congruent sounds compared to incongruent sounds, in a paradigm using a relative subtle manipulation of sound congruence (parchment vs polyester surface touching skin). However, no significant modulation on subjective ratings of illusion strength was observed in this experiment, or in a second experiment with more trials and more fine-grained visual analogue ratings scales. In the third experiment, we maximised the incongruence of the sound heard (a pure tone versus a soft brush) and the object saw and felt (a soft brush), and this audio-tactile incongruence produced a significantly diminishing effect on the subjective illusion as well as the proprioceptive drift. In conclusion, our findings suggest that the congruence of sounds and visuo-tactile information modulate the rubber hand illusion and that auditory feedback from bodily sounds influence our sense of own body.

Spatially mediated interactions between singletons in tactile search

Gherri, Elena[1]; Ambron, Elisabetta[2]
[1]University of Edinburgh, United Kingdom; [2]University of Delaware, USA;

In visual search tasks competitive interactions between target and distractor typically result in degraded target selection processes which increase as the target-distractor distance decreases. Here, we investigated for the first time whether analogous selective mechanisms operate within the somatosensory system. Specifically, we investigated whether the N140cc, an ERP component known to be associated with target selection in touch, changes as function of the target-singleton distractor distance in an additional singleton search task. Six simultaneous vibro-tactile stimuli were presented on each trial to three fingers of the left and right hand. Participants were asked to localise the singleton target (high frequency stimulus) while ignoring the singleton distractor (middle frequency stimulus) delivered to a different finger of the same hand as well as the homogenous distractors (low frequency stimuli) presented to the remaining fingers. The spatial separation between target and singleton distractor was varied according to both somatotopic space (singletons to contiguous or non-contiguous fingers) and external space (fingers open or closed). Behavioural results demonstrated that accuracy improved when target and distractor were close together than far apart with respect to both somatotopic and external distance. Thus, unlike vision, competition between singletons was reduced when their distance decreased. ERP results showed that the N140cc amplitude was enhanced when the somatotopic distance between target and singleton distractor increased (non-contiguous singletons), while it was reduced when their external distance increased (fingers open). These findings confirm the N140cc as an index of target selection and further suggest that this component is able to capture and distinguish the effects of different body representations (somatosensory and external) on tactile selective attention.

The representation of peripersonal space around upper and lower limbs

Xi, Aolong[1]; Sedda, Anna[2]; Gherri, Elena[1]
[1]University of Edinburgh, United Kingdom; [2]Heriot-Watt University;

Peripersonal space (PPS), the space closely surrounding the body, is typically characterised by enhanced multisensory integration. Neurophysiological and behavioural studies have consistently shown stronger visuo-tactile integration when a visual stimulus is presented close to the tactually stimulate body part in near space (within PPS) than in far space. However, in the majority of these studies tactile stimuli were delivered to the upper limbs, torso and face. Therefore, it is not known whether the space surrounding the lower limbs is characterised by similar multisensory properties. To address this question we asked participants to perform two versions of the classic visuo-tactile crossmodal congruency task in which they had to perform speeded elevation judgements of tactile stimuli presented to the dorsum of the hand and foot while a simultaneous visual distractor was presented at spatially congruent or incongruent locations either in near or far space. In line with existing evidence, when the tactile target was presented to the hand the size of the crossmodal congruency effect (CCE) decreased in far as compared to near space suggesting stronger visuo-tactile multisensory integration within PPS. By contrast, when the tactile target was presented to the foot, the CCE was weaker for visual distractor in near than far space. A follow-up study confirmed that these results were not driven by the effector used to execute the response. These findings show systematic differences between the representation of PPS around upper and lower limbs, suggesting that the multisensory properties of the different body-part centred representations of PPS are likely to depend on the potential actions performed by the different body parts.

The audiovisual advantage in pedestrians' road crossing decisions is significantly reduced for accelerating electric compared to conventional vehicles

Wessels, Marlene; Oberfeld-Twistel, Daniel
Johannes Gutenberg - Universität Mainz, Germany;

When crossing a road, pedestrians need to accurately judge the motion of approaching vehicles to avoid collisions. For vehicles with internal combustion engine (ICEVs), the vehicle sound provides salient auditory information about the acceleration state. For accelerating electric vehicles (EVs), the vehicle sound is less reflective of the vehicle's behavior. We investigated whether this sound difference leads to riskier road crossing decisions of pedestrians in interaction with EVs compared to ICEVs. In an interactive audiovisual virtual-reality simulation, a vehicle approached the participants on a one-lane street. The vehicle either initially approached at constant speed for 2 s and then accelerated positively for another 3s, or approached at a constant velocity for 5 s. The acoustic simulations of the vehicle were based on acoustic recordings of a real ICEV and of real EVs with an active or inactive acoustic vehicle alerting system (AVAS). For the ICEV, the probability of crossing decisions that would have resulted in a collision with the vehicle was lower than for the EVs and did not increase substantially with the acceleration level. In contrast, for the EVs, the collision probability was on average higher and increased significantly with the acceleration level. The AVAS reduced this effect slightly but did not remove it, so that crossing decisions were still riskier than for ICEVs. At a constant velocity, the collision probability was lower than for accelerated vehicle approaches and did not show significant differences between the vehicle types. Taken together, pedestrians are significantly less able to benefit from the sound emitted by an accelerating EV with and without AVAS for their crossing decisions, compared to the sound of an accelerating ICEV. This finding has important implications for traffic safety and for the design of AVAS technologies.

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The relationship between vestibular thresholds and balance tasks in a multisensory environment

Zanchi, Silvia[1,2]; Cuturi, Luigi F.[1,3,4]; Sandini, Giulio[1]; Gori, Monica[1]
[1]Italian Institute of Technology, Italy; [2]University of Genoa, Italy; [3]University of Bologna, Italy; [4]University of Turin, Italy;

Humans encode multiple sensory cues that guide balance, orientation, and navigation. Previous studies demonstrated that visual and vestibular inputs and auditory and vestibular inputs are integrated to improve self-motion perception. Interestingly, the vestibular system comprises an extended cortical network that integrates signals from multiple sensory modalities. The present study investigates the relationship between vestibular thresholds and the ability to exploit audio-vestibular signals for balance and motor coordination. Blindfolded healthy subjects participated in the study. The experiment was composed of three tests. In one test, we measured vestibular thresholds by administering passive whole-body rotations, translations, and eccentric rotations with a rotational-translational chair. In the second test, participants performed a static balance task (tandem Romberg task) on both foam/firm surfaces and, in the third test, a stepping test (Fukuda-Unterberger test). In all tests, participants could rely either on vestibular/proprioceptive or auditory cues, consisting of an earth-fixed intermitting white noise. In the three tests, we found no differences when comparing the performances with and without the auditory cue. We computed the multisensory gains (i.e., the difference between the measures in the multisensory conditions with the additional auditory cue and the measures in the vestibular/proprioceptive conditions), and we conducted a correlation analysis among them. Preliminary results show that the gain of the rotational components of vestibular thresholds tended to be positively correlated with the gain in the static balance task, especially with proprioceptive information (firm surface balance test), but tend to be negatively correlated with the gain in the dynamic stepping test. This finding suggests that factors related to the active control of movement may contribute to controlling balance and using environmental sources and perhaps compensate for weaker vestibular information processing. Further investigations are needed to unveil the contribution of audio-vestibular interaction to postural control, considering the potential clinical implications for multisensory rehabilitation procedures.

Vestibular cues to self-motion contribute to route memory and spatial navigation in a simulated driving task

Jabbari, Yasaman; Kenney, Darren M; Mohrenschildt, Martin Von; Shedden, Judith M
McMaster University, Ontario, Canada;

When driving in an unfamiliar environment, drivers use both self-motion and environmental landmark cues to navigate. Types of landmark cues can affect the efficiency of the navigation. For instance, proximal landmarks (e.g., gas station) provide local cues for route knowledge and distal landmarks (e.g., tall water tower outside of the town) provide spatial mapping cues. As far as we know, no research has examined the contribution of physical self-motion cues (e.g. vestibular) to specific route knowledge. Information from both optic flow and vestibular cues may contribute to the efficiency of use of route knowledge and navigation skills. The present study examined driving behaviour and route memory to observe the contribution of different self-motion and environmental cues to successful navigation. We used a motion driving simulator and manipulated the presence of vestibular cues during a spatial navigation task. Participants were trained to find a target location by driving along different routes through a virtual town. There were three different landmark conditions: proximal, distal, and no landmarks, and two different self-motion conditions: optic flow alone, and optic flow plus physical motion (e.g. forces due to acceleration and turning). Following the training, participants were tested on ability to find the target location along the trained routes. Vestibular and proprioceptive information from physical motion cues significantly improved navigation ability across all three landmark conditions. In particular, vestibular cues resulted in the greatest benefit to route knowledge accuracy when they coincided with proximal landmarks (e.g. a right turn at the gas station). Furthermore, vestibular cues affected acceleration and intensity of pressing the gas and brake pedals, possibly reflecting a greater sense of control of the virtual automobile. Our results suggest that vestibular cues can provide significant improvement for spatial navigation, especially when they coincide with proximal cues.

Impact of imposed physical distancing on multisensory experiences

Kirsch, Louise[1]; Spence, Charles[2]; Auvray, Malika[3]
[1]INCC, Université Paris Cité, Paris, France; [2]Department of Experimental Psychology, University of Oxford, Oxford, UK; [3]ISIR, Sorbonne Université, France;

In order to maintain our cognitive and emotional well-being during the COVID-19 lockdowns many of us may have felt the need to compensate for a lack of stimulation in certain sensory modalities and, in particular, a lack of touch. Our study aimed at investigating the influence of physical distancing on how different sensory modalities are craved for or experienced as compensation. To this aim, we conducted a first online experiment during one of the French lockdowns (May 2021, N=90), and a second experiment in Australia (September 2021), allowing a comparison, in the same country, between people in lockdown (N=160) and people without any restriction (N=160). In these studies, participants first rated images on how much they experienced the represented situation: before COVID-19-related restrictions, currently, and how much they would like to experience it. In order to tackle all sensory modalities, five categories of images were included: food, tactile interaction, music, sport, and visual arts. In addition, in order to compare whether it is more the sensory or the socialness that is lacked and craved for, the images involved a balance between social vs. non-social situations;. We also gathered control ratings of the images, and interindividual states such as loneliness and anxiety. Overall, people in lockdown were lacking sensory experiences in comparison to the group without restrictions, especially of social experiences; with the exception of non-social vision (e.g. people watching more TV). Noteworthy, the more lonely people are, the more people are craving for social touch in comparison to before but also the more they desire to experience social food. Altogether, these two experiments allow shedding light on how putting physical distance with others are shaping our sensory experience but also what we are craving for.

Multisensory Integration in Enhancing Affective Experience

Kim, SuKyoung
Sapporo City University, Japan;

The author has been researching experience design with focus on intuition and tacit knowledge which is relevant in case of decision-making in the design process and strategy. This research presents the model on how to structure the relationship of intuition, tacit knowledge, and experience towards enhancing affective experience through multisensory integration. A meta-analysis of affective experiences, such as pleasantness and unpleasantness, is driven through senses such as visual, tactile, auditory, etc. This means that pleasant experiences contribute to the individual's perceived values and reinforce personal affections. The present research focused on clarifying the role of individual experiences in modifying *the innate subjective filter* which is influenced and changed by the experiences considering the variety of subjectivity. This research clarified the gap between visual and olfactory perception with the same target stimuli to verify how to enhance the perceived value in multisensory integration by clarifying the influence of multisensory interference in visual-olfactory matching expectation to verify the question on which is more important to individual evaluation and emotion. Is *liking* an intuitive value that influences perceived stimuli preference? Does it verify the sensory difference between mono and multi intervention in evaluation? The results present that, perceived values are constructed from the distribution across both olfactory and visual structured sensory information in affective experience, but olfactory biases have more impact than that of visual in multi-sensory condition. It is deduced that a more ambiguous sensory information such as olfactory in this research is a more influential factor for evaluation and satisfaction.

Cross condition differences in multi-sensory sensitivities: insights from a mixed-methods approach

Price, Alice[1]; Ghaiwal, Abhay[1,2]; Griffin, Charlotte[1]; Sumner, Petroc[1]; Powell, Georgina[1]
[1]School of Psychology, Cardiff University, Cardiff, UK; [2]School of Medicine, Cardiff University, Cardiff, UK;

Differences in multi-sensory experiences (sensory sensitivities, sensation seeking, etc.) are commonly reported across a number of mental, neurological and neurodevelopmental conditions (e.g., Autism, ADHD, OCD, migraine, PTSD, PPPD, anorexia, anxiety). Much research in this area makes use of sensory questionnaires, asking the individual to report on the frequency of different, pre-defined sensory experiences. This study sought to determine to what extent these questionnaires reflect the qualitative experience of individuals across clinical conditions. Participants were recruited through the university and online support forums (total n = 739) and completed two quantitative measures of sensory sensitivity, as well as four qualitative, open response questions. These questions asked participants to detail their positive and negative sensory experiences across different modalities, as well as describe how these experiences impacted daily life, and how they related to their perception of self and others. Preliminary summative content analysis of modality specific words and phrases suggests that quantitative measures do not necessarily highlight the sensory modalities which are reported most frequently by individuals identifying with each clinical condition or area of neurodiversity. This may suggest that although quantitative questionnaire measures can provide valuable information on the presence of differences in multi-sensory processing, more targeted approaches may be needed to better understand the specific stimuli which affect individuals in their day-to-day life, particularly when questionnaires are developed with a specific population in mind. We propose an alternative questionnaire, early in its development, which seeks to better identify and differentiate modality-specific sensitivities across general population and clinical samples.

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Deficient Multisensory Integration with concomitant structural connectivity in adult ADHD

Schulze, Marcel; Lux, Silke; Philipsen, Alexandra
University Hopsital Bonn, Department of Psychiatry and Psychotherapy Germany;

Objective: Patients with Attention Deficit/Hyperactivity Disorder (ADHD) often report of being flooded by sensory impressions. Studies investigating sensory processing in adult ADHD show hypersensitivity for sensory inputs in especially the auditory domain. As everyday life situations occur not uni- but multimodal, the question arises, whether these unimodal hypersensitivities have consequences in multimodal scenarios. In the current study we investigate multisensory integration (MI) in an adult ADHD sample using the McGurk-effect. Further, we measured diffusion-tensor imaging. **Methods:** Twenty-five ADHD patients (6 females, age: 30.08 (SD:9,3) years) and twenty-four healthy controls (9 females; age: 26.88 (SD: 6.3) years) were recruited. MI was examined using the McGurk effect (MCG), where - in case of successful MI - incongruent speech-like phonemes between visual and auditory modality are leading to a perception of a new phoneme. Mann-Whitney-U test was applied to assess statistical differences between groups. Diffusion-weighted MRI (DWI) scan was acquired on a 3.0 Tesla scanner. Connectome was created and network-based statistics were performed with MRTRIX 3 and correlated to MCG. **Results:** Susceptibility to McGurk was significantly lowered for ADHD patients, as they relied more on the auditory domain. When ADHD patients integrated phonemes, reaction times were significantly longer. On the structural level, higher connectivity in ADHD was found between Heschl's Gyrus and auditory parabelt regions along with disrupted fronto-temporal network integrity compared to controls. **Conclusion:** The ability to integrate multisensory information is driven by a dominant bottom-up sensory processing of the auditory modality. On a structural level, there are overlapping inter-regional networks between the pathophysiology of ADHD and sensory processing /polymodal areas. MI deficits and the differences in respective network integration in ADHD might indicate that the frequently discussed maturational cortical delay extends to adulthood and underlies the continuance of the disorder over the age of adolescence.

Typical resting state activity of the brain requires visual input during an early sensitive period

Rączy, Katarzyna[1]; Hölig, Cordula[1]; Guerreiro, Maria J. S.[1,2]; Lingareddy, Sunitha[3]; Kekunnaya, Ramesh[4]; Röder, Brigitte[1]
[1]University of Hamburg; [2]Carl Von Ossietzky University of Oldenburg; [3]Lucid Medical Diagnostics Banjara Hills; [4]Jasti V Ramanamma Children's Eye Care Center, Child Sight Institute, LV Prasad Eye Institute;

Sensory deprivation, following a total loss of one sensory modality e.g. vision, has been demonstrated to result in compensatory plasticity. It is yet not known to which extent neural changes, e.g. higher resting state activity in visual areas (cross-modal plasticity) as a consequence of blindness, reverse, when sight is restored. Here, we acquired BOLD resting state activity during an eyes open (EO) and an eyes closed (EC) state in congenital cataract-reversal individuals (CC), developmental cataract-reversal individuals (DC), congenitally permanently blind individuals (CB) and sighted controls (SC). The amplitude of low frequency fluctuations (ALFF) of the BOLD signal - a neural marker of spontaneous brain activity during rest - was analyzed. In accord with previous reports, in SC individuals ALFF was significantly higher in the EO than in the EC in visual association areas and in parietal cortex but significantly lower in auditory and sensorimotor cortices. In CC individuals, ALFF was increased in visual cortex in the EO as compared to the EC too but this increase was larger in amplitude than in SC participants. In contrast, CC individuals lacked a similar increase in parietal regions and did not show the typical decrease of ALFF in auditory cortex. CB individuals displayed an overall higher ALFF in visual cortex compared to SC individuals and compared to CC individuals in the EC condition. Higher ALFF in visual cortex of CC than SC individuals during EO might indicate an altered excitatory-inhibitory balance of visual neural circuits. By contrast, the lower parietal increase and the missing downregulation in auditory regions suggest a reduced influence of the visual system on multisensory and the other sensory systems after restoring sight in CB individuals. These results demonstrate a crucial dependence of visual and multisensory neural system functioning on visual experience during a sensitive phase in human brain development.

PsySuite: performing multimodal portable psychophysics within the Android environment

Domenici, Nicola; Inuggi, Alberto; Tonelli, Alessia; Gori, Monica
Istituto Italiano di Tecnologia, Genova, Italy;

Despite its charm, psychophysics is notoriously considered tedious by most participants, as well as being often significantly time-consuming. In addition to that, to obtain psychophysical measurements participants are required to reach research facilities, which has become problematic since the COVID-19 pandemic. Here we challenge these issue by introducing PsySuite, an Android App designed to foster a remote approach to multimodal behavioral testing. To assess the App's reliability, we performed both a hardware and a behavioral validation. First, we evaluated generated stimuli's accuracy (onset, offset, and multimodal simultaneity) and precision (stability of a given pattern across trials), recording stimuli's traces with a TDS 2014b Tektronix oscilloscope. Within PysSuite, we then developed portable versions of two classic psychophysical paradigms (the double-flash illusion and a temporal discrimination task). Using the App, we evaluated perceptual performance in a total of 22 participants, and we compared measurements obtained with PsySuite against performance measured via a canonical PC-based setup. Our results showed that PsySuite could steadily reproduce stimuli with a minimum of 7ms, 17ms, and 30ms for the auditory, visual, and tactile modalities, respectively. Furthermore, perceptual performances obtained with PsySuite were consistent with the corresponding performances evaluated using the more canonical PC-based setup. Combined with the high accessibility of testing procedures introduced with PsySuite, these findings suggest that the App can be reliably used to evaluate perceptual performance and set psychophysics to a cheap, user-friendly, and portable level.

Cross-sensory inhibition or unisensory facilitation: neural architecture of multisensory processing

Cuppini, Cristiano[1]; Ursino, Mauro[1]; Magosso, Elisa[1]; Crosse, Michael J.[2]; Foxe, John J.[2,3]; Molholm, Sophie[2,3]
[1]University of Bologna, Italy; [2]Albert Einstein College of Medicine, Bronx, NY; [3]University of Rochester School of Medicine and Dentistry, Rochester, NY;

In a simple reaction time task in which auditory and visual stimuli are presented in random sequence alone (A or V) or together (AV), there is a so-called reaction time (RT) cost on trials in which stimulus modality switches (A/V) compared to when it repeats (A/A). This is always true for unisensory trials, whereas RT to an AV stimulus preceded by a unisensory stimulus is statistically comparable with the Repeat condition (AV/AV). Neural facilitation for Repeat trials **or** neural inhibition for Switch trials could both account for these effects. Here we used a neural network model to test the ability of these two distinct mechanisms, inhibition and facilitation, to produce the specific patterns of behavior that we see experimentally, modeling switch and repeat trials as well as the influence of the interval between the present and the previous trial. The model results are consistent with an inhibitory account in which there is competition between the different sensory modalities, instead of a facilitation account in which the preceding stimulus sensitizes the neural system to its particular sensory modality. Moreover, the model shows that the multisensory integration can explain the results in case of crossmodal stimuli, where the preceding stimulus has little effect. This is due to faster dynamics for multisensory integration compared to cross-sensory inhibition. These findings link the cognitive framework delineated by the empirical results to a plausible neural implementation and provide a valuable tool that can be used to study and explain the acquisition of multisensory abilities in subjects with a neurotypical development and subjects with deficits commonly reported in children with ASD.

Crossmodal central tendency effect of duration discrimination is dependent on stimulus order

Gao, Yi; Miller, Kamilla; Rudd, Michael; Webster, Michael; Jiang, Fang
University of Nevada, Reno, United States of America;

Integrating visual and tactile information in the temporal domain is critical for active perception. To accomplish this, coordinated timing is required. Here, we study perceived duration within and across these two modalities. Specifically, we examined how duration comparisons within and across vision and touch were influenced by temporal context and presentation order using a two-interval forced choice task. We asked participants to compare the duration of two temporal intervals defined by tactile or visual events. Two constant standard durations (700 ms and 1,000 ms in 'shorter' sessions; 1,000 ms and 1,500 ms in 'longer' sessions) were compared to variable comparison durations in different sessions. In crossmodal trials, standard and comparison durations were presented in different modalities, whereas in the intramodal trials, the two durations were presented in the same modality. The standard duration was either presented first () or followed the comparison duration (). In both crossmodal and intramodal conditions, we found that the longer standard duration was overestimated in trials and underestimated in trials whereas the estimation of shorter standard duration was unbiased. Importantly, the estimation of 1,000ms was biased when it was the longer standard duration within the shorter sessions but not when it was the shorter standard duration within the longer sessions, indicating an effect of temporal context. The effects of presentation order can be explained by a central tendency effect applied in different ways to different presentation orders. Both crossmodal and intramodal conditions showed better discrimination performance for trials than trials, supporting the Type B effect for both crossmodal and intramodal duration comparison. Moreover, these results were not dependent on whether the standard duration was defined using tactile or visual stimuli. Overall, our results indicate that duration comparison between vision and touch is dependent on presentation order and temporal context, but not modality.

Wednesday Morning Posters

Wednesday Morning Posters

11:15am - 12:15pm

Mindfulness meditation biases visual temporal order discrimination but not in temporal ventriloquism

Tian, Yue; Chen, Lihan
Peking University, China, People's Republic of;

Previous relevant studies have used temporal bisection task and mainly indicated the temporal dilation effect, due to the attentional focus after mindfulness meditation. However, those studies have adopted the stimuli with a wide time range (sub-second and above seconds) by focusing on the duration perception of the stimuli. Here we asked whether a long mindful training would modulate the temporal order judgment on a sub-second scale, to confine the temporal processing on perceptual level. We used the temporal ventriloquism paradigm in which the observers fulfilled a temporal order judgment (TOJ) upon two visual discs (with gap interval of 0, 50, 100, or 150 ms) appearing at the left or right on the screen, with or without the concurrent paired beeps. When presented, the sound beeps were either synchronized with the two discs, or enclosed the visual stimuli by leading 50 ms to the first disc and the other lagging by 50 ms, respectively. In pre-test and post-test, both training and control groups did the TOJ tasks. During the interim session, the training group received a rigorous mindful training which took 2.5 hours each week, and lasted for totally 8 weeks. We found larger changes point of subjective equalities (PSEs) in visual-only condition after training, indicated a bias of TOJ (typically with perceived order from left disc to right one). The PSE changes were positive correlated with Five Facet Mindfulness Questionnaire in the factor of "acting with awareness", showing the moment-to-moment time awareness and enhanced attention focus prolonged the stimuli durations but reduced the perceived gap duration in between target visual stimuli. This bias was abolished by the temporal ventriloquism effect, in which the concurrent sounds 'pulled' the visual discs away and counteract the 'compression'. The stable JNDs ruled out the account of timing sensitivities modification (i.e., arousal changes).

Unpredictability of correlated sensory signals does not enhance multisensory integration

Fuchs, Xaver; Wittbrock, Carolin; Heed, Tobias
Bielefeld University, Germany;

Many studies show that multisensory integration depends on spatiotemporal proximity. In real life, a sensory source often emits continuous fluctuating multisensory signals that are correlated over time. For example, a speaker's voice and the visible shape of the mouth change in synchrony. A recent model, the Multisensory Correlation Detector (MCD; Parise & Ernst, 2016), accurately predicts participants' common cause attributions for stimulus series based on their temporal correlation. However, correlations do not express whether stimulus sequences are predictable (i.e., regular) or unpredictable. Evidence for a common cause, however, might be higher for unpredictable correlated patterns because two unpredictable, yet correlated, patterns are unlikely to happen by chance, caused by two independent sources. This idea is not captured by the MCD model. Here, we tested whether unpredictability boosts common cause attributions. We conducted two experiments that resembled the ones testing the MCD model. In Experiment 1 (N=15), we presented visual-auditory sequences (using an LED and a speaker) that lasted for 15 s and varied in their degree of synchrony and predictability. Participants rated perceived synchrony, predictability, and likelihood of a common cause. Experiment 2 (N=15) was similar but used visual and tactile stimuli (on the hand) and also varied spatial proximity between the hand and the LED. In both experiments we also assessed the temporal binding window (TBW) for the stimulus combinations using temporal order judgment tasks. Participants assigned highest common cause judgments to highly synchronous and highly predictable patterns. For patterns with low synchrony, ratings were slightly higher when the patterns were also unpredictable. The TBW and spatial proximity did not affect common cause attributions. Our experiments did not support our hypothesis that multisensory integration is boosted by unpredictability and we conclude that the brain primarily uses synchrony of signals as evidence for a common cause.

Characterising the neural correlates of cross-modal associations formed from unisensory stimulus presentations: a neurally-informed modelling approach

Bolam, Joshua William[1]; Boyle, Stephanie Claire[2]; Ince, Robin A.A.[2]; Delis, Ioannis[1]
[1]School of Biomedical Sciences, The University of Leeds, LS2 9JT, United Kingdom; [2]Institute of Neuroscience and Psychology, The University of Glasgow, G12 8QB, United Kingdom;

Cross-modal associations refer to implicit mappings made between stimuli from different sensory modalities, and are used to process multisensory information. For example, high-pitch tones are mapped with small visual objects, and vice versa. Preferential, or *congruent*, cross-modal associations have been shown to increase accuracy and reduce reaction times (RTs) across perceptual decision-making paradigms, even when only unisensory stimuli are presented. However, the neural correlates underpinning such benefits to perceptual decision-making remain unclear. We sought to identify *when* perceptual improvements from associative congruency emerge in the brain during decision formation, i.e. whether they represent 'early' sensory processing benefits, or 'late' post-sensory changes in decision dynamics. Using a modified version of the Implicit Association Task (IAT), coupled with electroencephalography (EEG), we measured the neural activity underlying the effect of auditory stimulus-driven pitch-size associations on perceptual decision formation. Behavioural results showed that participants responded significantly faster during trials when auditory pitch was *congruent*, rather than *incongruent*, with its associative visual size counterpart. To decode single-trial EEG activity, we employed two complementary multivariate linear discriminant analysis techniques to characterise the spatiotemporal dynamics of EEG activity underpinning IAT performance. EEG decoding revealed two distinct neural components encoding auditory congruency irrespective of the presented stimulus feature: an 'early' component (~120ms post-stimulus, coinciding with the time of maximal discrimination of the auditory stimuli) including lateralised occipito-temporal and frontal activations, and a 'late' component (~350ms post-stimulus) with a fronto-central topography. Preliminary application of the Hierarchical Drift Diffusion Model, a Bayesian model of decision-making behaviour, indicated associative congruency expedites the integration of sensory evidence and decreases inter-trial variability in the duration of non-decisional processes. Together, our results suggest that, through repeated unisensory stimulus presentations, 'late' post-sensory representations of associative congruency may also become encoded in 'early' sensory processing of unisensory features, thereby increasing the speed of perceptual decision formation.

Characterizing auditory and visual motion processing and integration in hMT+/V5 and Planum Temporale with ultra-high-field fMRI (7T).

Barilari, Marco[1]; Gau, Remi[1]; Collignon, Olivier[1,2,3]
[1]Université Cathoulique de Louvain, BelgiumInstitute of research in Psychology (IPSY) & Institute of Neuroscience (IoNS), University of Louvain (UCL), Louvain-la-Neuve, Belgium; [2]School of Health Sciences, HES-SO Valais-Wallis, Sion, Switzerland; [3]The Sense Innovation and Research Center, Lausanne and Sion, Switzerland;

The ability of the brain to integrate motion information originating from separate sensory modalities is fundamental to efficiently interact with our dynamic environment. The human occipito-temporal visual region hMT+/V5 and the auditory area Planum Temporale (PT) are known to be highly specialized to process visual and auditory motion directions, respectively. In addition to their role in processing the dominant sensory information, it was recently suggested that these regions may also engage in crossmodal motion processing. How multisensory information is represented in these regions remain however poorly understood. To further investigate the multisensory nature of hMT+/V5 and PT, we characterized single-subject activity with ultra-high field (UHF) fMRI (7T) when participants processed horizontal and vertical motion stimuli delivered through vision, audition, or a combination of both modalities simultaneously. Our preliminary results confirmed that in addition to a robust selectivity for visual motion, portion of hMT+/V5 selectively responds to moving sounds and a portion of PT responds to moving visual stimuli. We are now further characterizing the brain activity in the cortical depths using UHF fMRI combined with vascular space occupancy (VASO) recording at high spatial resolution (.75mm isotropic). We hypothesize that hMT+/V5 and PT might encode auditory and visual motion information in separate cortical layers, reflecting the feed-forward versus feed-back nature of how sensory information flows into those regions. This project will shed new lights on how crossmodal information is represented across the depth of the cortical layers of motion selective human brain areas.

EEG evoked activity suggests amodal evidence integration in multisensory decision-making

Schaffhauser, Thomas; De Cheveigné, Alain; Boubenec, Yves; Mamassian, Pascal
Ecole Normale Superieure and CNRS, Paris, France;

Recent works in neuroimaging have revealed neural signatures of evidence integration (O'Connell et al., 2012, Nat Neuro; Philiastides et al., 2014, J Neuro) that reflect the ramping activity of neurons in the parietal cortex. While these experiments focused on unisensory visual and auditory perceptual decision-making, it is unclear to what extent the neural correlates of multisensory evidence integration are shared with their unisensory counterparts. To address this issue, we designed a change detection paradigm in which twenty-one participants monitored a continuous stream of visual random dot motion and auditory tone clouds. The random dot motion was displayed within a circular aperture and consisted of 200 small dots repositioned every 50 ms. The tone clouds consisted of 10 simultaneous 50 ms pure tones drawn from a range of 6 octaves (220 to 14,080 Hz) with a resolution of 12 semitones per octave. In this continuous bimodal stream, participants had to detect unisensory changes (a change from incoherent noise to a coherent pattern of upward moving dots or rising tone sequences) or bimodal changes (simultaneous auditory and visual changes in coherence) while continuous EEG was acquired via 64 scalp electrodes. EEG activity was denoised with spatial filtering techniques to isolate components that capture neural activity most reproducibly evoked by stimulus change onset (de Cheveigné & Simon, 2008, J Neuro Methods). EEG evoked activity could be discriminated between visual and auditory target stimuli highlighting separable encoding of visual and auditory coherence changes. Further analyses revealed a component rising before participants response that echoes evidence accumulation and appeared to be common for both unisensory (visual, auditory) and redundant audio-visual changes. These results point to a single amodal accumulator that integrates evidence coming from each sensory modality in isolation or a combined bimodal signal.

Modulation of perception by visual, auditory and audiovisual reward predicting cues

Antono, Jessica Emily; Pooresmaeili, Arezoo
European Neuroscience Institute - Göttingen, Germany;

Rewards influence information processing in the primary sensory areas specialized to process stimuli from a specific sensory modality. In real life situations, we receive sensory inputs not only from one single modality, but stimuli are often multisensory. *It is however not known whether reward-driven modulation of perception follows the same principles when reward is cued through a single or multiple sensory modalities.* We previously showed that task-irrelevant reward cues modulate perception both intra- as well as cross-modally, likely through a putative enhancement in the integration of stimulus parts into a coherent object. In this study, we explicitly test this possibility by assessing whether reward enhances the supra-additive integration of unisensory components of a multisensory object. Towards this aim, we designed a simple detection task using reward predicting cues that were either unisensory (auditory or visual, both above the detection threshold) or multisensory (audiovisual). We expected that reward speeds up reaction times in response to all stimulus configurations, and additionally reward effects in multisensory cues fulfills the supra-additive principle of multisensory integration. We observed that reward decreased response times with the strongest effect found for multisensory stimuli. However, this behavioral effect did not reach the supra-additive threshold. Neuroimaging results demonstrated supra-additive responses to audiovisual stimuli in areas such as the Superior Temporal Sulcus (STS) that are known to be involved in audiovisual integration. However, reward did not enhance the supra-additivity in STS compared to a no reward condition. Overall, our results indicate that reward does not enhance multisensory integration through a supra-additive rule.

Wednesday Morning Posters

Wednesday Morning Posters

11:15am - 12:15pm

Representation of emotion expressions along the face and voice networks

Falagiarda, Federica[1]; Gau, Rémi[1]; Battal, Ceren[1]; Rezk, Mohamed[1]; Van Audenhaege, Alice[1]; Collignon, Olivier[1,2,3,4]

[1]University of Louvain (UCL), Belgium; [2]University of Trento, Italy; [3]School of Health Sciences, HES-SO Valais-Wallis, Sion, Switzerland; [4]The Sense Innovation and Research Center, Lausanne and Sion, Switzerland;

Efficient discrimination of emotion expressions from facial and vocal signals is a key perceptual process for successful everyday social interactions. A comprehensive characterization of which regions of the face-processing and voice-processing networks engage in the representation and integration of emotional expressions from both modalities remains unresolved. We characterized the brain activity of 24 participants, each undergoing 3h of functional-MRI recordings while presented with dynamic facial and vocal expressions from five basic emotional categories, unimodally and bimodally. We localized the core face and voice processing regions in each participant through dynamic functional localizers and then analysed the data in the individually defined areas, through multivariate pattern classification. The analysis reveals that information about discrete facial emotions is found in all regions of the face network, and information about vocal emotions is found in all regions of the voice network. The identified face and voice networks overlap along the middle temporal gyrus (MTG) and in the frontal cortex (FC), bilaterally. In these regions, as well as in the visually-defined posterior superior temporal sulcus (pSTS), emotion expressions could be decoded from both the faces and the voices, and successful cross-modal decoding additionally revealed that a shared brain code exists between the different modalities in these areas. In conclusion, we found that facial and vocal emotion expressions can be respectively decoded across all regions of the face and voice networks, arguing against the idea that such information is solely represented in sub-parts of those networks. Notably, we demonstrated that the MTG, the pSTS and the FC represent emotion expressions through a code that is, at least partly, common between – hence independent of – the sensory modality of the input.

Neural Mechanisms Underlying the Reversal of Hemianopia with Multisensory Training

Stein, Barry E.[1]; Rowland, Benjamin A.[1]; Monti, Melissa[2]; Magosso, Elisa[2]; Cuppini, Cristiano[2]

[1]Department of Neurobiology and Anatomy, Wake Forest School of Medicine, Winston-Salem, NC, USA; [2]Department of Electrical, Electronic, and Information Engineering "Guglielmo Marconi", University of Bologna, Bologna, Italy;

Extensive damage to visual cortex on one side of the brain often induces a profound blindness in contralesional space (hemianopia). Fortunately, visual responsiveness can be restored within a few weeks by a non-invasive sensory training paradigm in which auditory-visual stimulus pairs are repeatedly presented in the blinded hemifield. Converging empirical evidence suggests that this training induces a reorganization within remaining visual circuits involving the midbrain superior colliculus (SC). The present study extends our computational model of this circuit (Cuppini et al., 2018) to explain this functional reorganization and the return of visually-guided behaviors. In the model, lesions of visual cortex remove significant sources of visual input to its cortical and subcortical targets and indirectly damages them through secondary (excitotoxic) injuries. This renders neurons in association cortex (AEV) and SC deep layers (SCd) unresponsive to visual cues (Jiang et al., 2009). Visual inputs to AEV from the superficial SC (sSC) through pulvinar (P) are retained but are too weak to drive neural activity. During auditory-visual training, auditory inputs activate SCd neurons, which send feedback signals to AEV. These signals converge with the inputs from pulvinar to activate AEV neurons and engage normalizing Hebbian mechanisms previously used to explain development and plasticity in this circuit. These dynamics create a strong functional loop (SCs->P->AEV->SCd) that is capable of supporting visually-guided behavior in animals in which the geniculostriate pathway has been destroyed. The model explains all empirical findings in this model system to date within a unified framework, and suggests new directions for future research. Supported by NIH grants EY024458 and EY026916

Audio-visual spatial aftereffects are based on multisensory perception and approximately optimal recalibration

Kramer, Alexander; Bruns, Patrick; Röder, Brigitte

Universität Hamburg, Germany;

Multisensory integration of spatially discrepant audio-visual stimuli results in a shift of auditory localization towards the visual stimulus (ventriloquism effect, VE). The size of the VE has been shown to depend on the relative reliabilities of the auditory and visual stimuli. Moreover, spatially misaligned visual and auditory stimulation leads to a recalibration of auditory localization both after a single exposure (immediate ventriloquism aftereffect, iVAE) and after a longer lasting exposure to consistently misaligned audio-visual stimuli (cumulative ventriloquism aftereffect, cVAE). Here we investigated whether both aftereffects depend on relative reliabilities and whether the immediate aftereffect depends on the task-relevant sensory modality. Thirty-two healthy adults participated in two sessions, one with a highly reliable visual stimulation, one with a low reliable visual stimulation (random dot patterns with gaussian luminance envelopes of different size). Two sounds (different pitch) were paired with visual stimuli (unique color) and presented with opposite directions of audio-visual spatial discrepancies (13.5° to the left or right). Either the auditory or visual component had to be localized. Both auditory and visual unimodal stimuli were intermixed to measure auditory and potential visual aftereffects. We found a frequency specific auditory cVAE and an auditory iVAE that generalized across frequencies. Importantly, the auditory cVAE was reduced in the low visual reliability condition. Moreover, when the visual component of the crossmodal stimulus had to be localized, the auditory iVAE was larger compared to when the auditory component had been task-relevant. Finally, we observed a visual VE that was increased in the high visual reliability condition. By contrast a visual aftereffect was not observed. These results demonstrate an often neglected visual VE, which showed the expected reliability dependence. Our results further suggest that cumulative crossmodal recalibration similarly depends on bottom-up sensory reliabilities and that immediate crossmodal recalibration seems to integrate top-down driven task demands.

Strategic re-aiming decreases perceptual precision during motor adaptation

Will, Matthias[1,2]; Stenner, Max-Philipp[1,2]

[1]Otto-von-Guericke Universität Magdeburg, Germany; [2]Leibniz Institut für Neurobiologie Magdeburg, Germany;

The precision, or reliability, with which we perceive sensory consequences of our own motor commands is thought to depend partly on an internal model that predicts these consequences. When sensorimotor contingencies change, and predictions are violated, e.g., early during sensorimotor adaptation, perceptual precision should decrease. Here, we test this idea. In four experiments, healthy young volunteers repeatedly adapted to a 45° visuomotor rotation for 2-4 reaches (rotation mini-block), followed by 2-4 washout reaches (washout mini-block). In different experiments, individuals were instructed either to use an aiming strategy that fully compensated for the rotation, or to ignore the rotation, and to “aim directly” at the target. Any adaptation was therefore implicit. Across all experiments, visual feedback was omitted on the second, third, or fourth trial of each mini-block, and participants localized their unseen hand. We estimated the precision of position sense by computing variability of hand localization across mini-blocks. We found implicit motor adaptation as indicated by reach after effects as early as after a single rotation trial. Importantly, we observed an increase in inter-quartile-range of angular localization errors, as evidence of a decrease in perceptual precision, in rotation blocks, compared to washout blocks, but only when participants used an instructed aiming strategy. Inter-quartile-range did not change when participants ignored the rotation, and aimed directly for the target. Different methods for reporting hand location did not influence our results. We conclude that a change in sensorimotor contingencies alone does not alter the precision of positions sense, while a re-aiming strategy, or the presence of aiming targets, decreases precision. We attribute this decrease to splitting of spatial attention. A decrease in perceptual precision due to strategic re-aiming may have important implications for implicit motor adaptation, and shape the interplay between implicit and explicit learning.

The effect of Audio-visual-haptic Training on Learning in a Virtual and Physical Environment

Batterley, Michael David Sheldon

University of Liverpool, United Kingdom;

The performance of some sequence-based tasks, such as driving a car, have the potential for deadly consequences if performed incorrectly. Therefore, the methods used to teach individuals how to perform such tasks should be as effective as possible at achieving their respective learning outcomes. Virtual Reality (VR) has been used to safely and effectively teach users to perform various tasks. The inclusion of additional multisensory cues (MSCs) in VR has the potential to further improve learning. Here we test whether VR with and without the inclusion of these MSCs leads to a significant improvement in sequence learning compared to a physical environment. Fourteen participants were presented with four buttons on a board and tasked with pressing the highlighted button under three separate conditions. Condition 1 was performed in VR without MSCs (VR Non MSC). Condition 2 was performed in VR with visual, auditory and haptic MSCs (VR MSC). Condition 3 was performed on a physical board without MSCs (Physical). The highlighted buttons were presented in either a random or repeating six sequence pattern depending on the block. Accuracy and response times were recorded. The results show that the addition of multisensory cues in a VR environment leads to a significant reduction in reaction times. Whilst a significant difference in reaction time between the Physical and VR Non MSC was also found, there was no significant difference between VR MSC and the Physical condition. As lower reaction times indicate sequence learning, these findings show that the inclusion of MSCs can improve people’s ability to learn sequences. Furthermore, as there was no significant difference between learning in the VR MSC and Physical conditions, it suggests that VR could be an effective sequence learning tool in the absence of a suitable physical environment.

The dynamic interplay of multisensory and motion influences on visual completion

Kurian*, Grace S.[1,3]; Retsa*, Chrysa[1,2,3]; Murray, Micah M.[1,2,3]

[1]Laboratory for Investigative Neurophysiology (the LINE), Radiology Department of Radiology, Lausanne University Hospital and University of Lausanne, Lausanne, Switzerland; [2]CIBM Center for Biomedical Imaging, Lausanne, Switzerland; [3]The Sense Innovation and Research Center, Lausanne and Sion, Switzerland;

Object processing occurs within a dynamic, multisensory environment and is robust to impoverished or noisy conditions. Visual borders can be perceived across regions without contrast gradients. These so-called illusory contours (IC) have been extensively used in laboratory settings. Event-related potentials (ERPs) have characterized the neural correlates of IC perception; referred to as the IC-effect, which is an enhanced posterior scalp negativity at ~100-200ms post-stimulus onset with generators principally within the lateral occipital cortices. The IC-effect has been documented across a wide range of stimulus parameters. To date, however, there has been scant investigation of mechanisms subserving the perception of ICs induced by moving stimuli. This is important to resolve, in part, because both motion and IC processing are often impaired in sight-restored children, impacting their scholastic achievement and more generally their quality of life. One potential facilitative contribution to this issue stems from our laboratory’s recent demonstration that IC processes are subject to cross-modal influences. Sounds facilitate IC perception both behaviorally and via enhancement of the IC-effect. This discovery ought also be considered alongside concomitant evidence for preferential integration of audio-visual looming motion stimuli. The present study therefore investigated the behavioral and ERP correlates of influences of audio-visual looming motion on IC processes. We hypothesized that moving stimuli will enhance IC perception and will further benefit from multisensory motion signals. We used a novel visual completion paradigm with looming and stationary IC and no-contour (NC) stimuli in the presence or absence of congruent sounds, while 128-channel ERPs were recorded from 23 healthy participants. ERPs were analysed within an electrical neuroimaging framework. Both sound and movement synergistically interact to enhance IC processes as early as 80ms post-stimulus. Our results pave a pathway for understanding visual completion in more naturalistic contexts and for applying such to improve visual rehabilitation.

Wednesday Afternoon Talks

Wednesday Talks

13:15am - 14:45am

Room Danube

Multisensory Development

1:15pm - 1:30pm

A brief period of postnatal visual deprivation selectively alters visual motion processing in early visual regions

Rezk, Mohamed[1]; Mattioni, Stefania[1]; Gau, Remi[1]; Nam, Junghyun[2]; Liu, Zhong-Xu[3]; Gao, Xiaoqing[4]; Lewis, Terri[5]; Maurer, Daphne[5]; Collignon, Olivier[1,6]
[1]Université catholique de Louvain (UCLouvain), Belgium; [2]University of Toronto, Canada; [3]University of Michigan-Dearborn, USA; [4]Zhejiang University, China; [5]McMaster University, Canada; [6]University of Trento, Italy;

How does early visual experience shape the development of the visual motion network? Previous behavioral studies indicate that early visual deprivation leads to later deficits in processing global motion (Ellemberg et al., 2002). Here we used functional magnetic resonance imaging to characterize the underlying neural pathways. Specifically, we compared brain responses elicited by visual motion in adults born with dense bilateral cataracts who were treated early in life (n=15, mean period of visual deprivation ± SD= 71 ± 48 days) to those of age-matched adults with typical visual development (n=17). The patients showed reduced recruitment of early visual areas while processing motion information when compared to controls, and the longer the period of visual deprivation, the lower the motion preference shown by V1. Importantly, no alterations were observed in the response profile of the motion selective area hMT+/V5. Multivariate pattern analysis revealed that the accuracy of decoding the direction of visual motion was reduced significantly for patients (compared to controls) in V1, but not in hMT+/V5. Psychophysiological interaction analyses demonstrated reduced connectivity between hMT+/V5 and V1 during visual motion processing. Moreover, resting state data confirmed that the connectivity profile of V1 was altered in the patients. Together, these results suggest that a brief and transient period of bilateral visual deprivation early in life has a region-specific impact on the visual motion network with V1 being permanently affected but hMT+/V5 showing resilience to deprivation.

1:30pm - 1:45pm

Effects of early auditory deprivation on visuo-tactile temporal processing

Jiang, Fang; Chifamba, Kudzai; Scurry, Alexandra N.
UNR, United States of America;

Studies of compensatory plasticity in early deaf (ED) individuals have mainly focused on unisensory processing, and on spatial rather than temporal coding. However, precise discrimination of the temporal relationship between stimuli is imperative for successful perception of and interaction with the complex, multimodal environment. Although the properties of cross-modal temporal processing have been extensively studied in neurotypical populations, remarkably little is known about how the loss of one sense impacts the integrity of temporal interactions among the remaining senses. To understand how auditory deprivation affects multisensory temporal interactions, ED and age-matched normal hearing (NH) controls performed a visual-tactile temporal order judgment task in which visual and tactile stimuli were separated by varying stimulus onset asynchronies (SOAs) and subjects had to discern the leading stimulus. Participants performed the task while EEG data were recorded. Group averaged event-related potential waveforms were compared between groups in occipital and fronto-central electrodes. Despite similar temporal order sensitivities and performance accuracy, ED had larger visual P100 amplitudes for all SOA levels and larger tactile N140 amplitudes for the shortest asynchronous (± 30 ms) and synchronous SOA levels. The enhanced signal strength reflected in these components from ED adults are discussed in terms of compensatory recruitment of cortical areas for visual-tactile processing. In addition, ED adults had similar tactile P200 amplitudes as NH but longer P200 latencies suggesting reduced efficiency in later processing of tactile information. Overall, these results suggest that greater responses by ED for early processing of visual and tactile signals are likely critical for maintained performance in visual-tactile temporal order discrimination.

1:45pm - 2:00pm

Interactions between auditory statistics processing and visual experience emerge only in late development

Berto, Martina; Ricciardi, Emiliano; Pietrini, Pietro; Bottari, Davide
MOMILab, IMT School for Advanced Studies Lucca, Italy;

The auditory system relies on local and global representations of sounds. As the amount of entering local features increases, global representations based on summary statistics emerge. We investigated whether visual experience influences the development and functioning of these two fundamental sound computations, local and global processing. We exploited a previously validated computational synthesis approach to generate sounds in which it was possible to control for embedded statistical properties. By manipulating the duration of these synthetic sounds, we were able to systematically tackle the efficiency of either local or global processing of the auditory system. We tested samples of sighted controls (SC), congenitally blind (CB), and late-onset blind (LB) individuals in two experiments. In experiment 1, performance relied on local features analysis; in experiment 2, performance benefited from computing global statistical representations. In both experiments, SC and CB performance was remarkably overlapping, providing evidence that the auditory computations tested here can develop independently from visual inputs availability in early development. Conversely, LB performed systematically worse than the other groups when good performance required relying on local features. No alterations were found in the LB group's ability to compute global representations. These findings suggest that the efficiency of local auditory processing can be hampered in case, at later developmental phases, sight becomes unavailable. The data support the existence of an audio-visual interplay for the processing of auditory details that emerges only in late development and reveal a functional adaptation to visual loss.

2:00pm - 2:15pm

How vision shapes the development of allocentric spatial frame

Bollini, Alice; Gori, Monica
Unity for Visually Impaired People (U-VIP), Italian Institute of Technology (IIT), Italy;

Spatial cognition is the ability that allows us to move through the environment by relevance and updating our body's position while walking. This ability is based on the spatial reference system consisting of two types of coordinates: egocentric (encoding in relation to one's own body) and allocentric (encoding based on relationships between objects). It has been shown that the development of allocentric coordinates is driven by vision, whereas egocentric coordinates are present from the earliest moments of life. In adults with visual impairment, the allocentric system is impaired; much less is known about how visual impairment affects the development of spatial cognition during growth. In this study, we tested the spatial abilities of children with visual impairment to assess how the impairments influence the development of spatial cognition. We employed Simon's task to investigate spatial competence development in the visual and auditory modalities. Then, we introduced a coordinates' conflict situation by making children perform the task with their hands crossed. In this way, the right hand is in the left space and vice-versa. The results show that sighted children progress over time to reach allocentric system maturity with no difference between visual and auditory performance. In contrast, children with severe visual impairment show a delay in the development of spatial cognition, exhibiting a decreased performance with crossed hands only in the visual condition, but with similar performance to sighted children in the auditory modality. Finally, blind children showed impaired performance in the auditory modality. These results showed how vision has a causal role in developing an allocentric frame in multiple domains. Indeed, even low residual vision is sufficient for the correct development of the allocentric coordinates in the auditory modality but not in vision. In contrast, the complete absence of vision also determines an impairment in the auditory modality.

2:15pm - 2:30pm

The development of cortical activity during waking and sleep stages in children with and without visual impairment

Vitali, Helene[1,2]; Campus, Claudio[1]; Signorini, Sabrina[3]; De Giorgis, Valentina[3]; Gori, Monica[1]
[1]Italian Institute of technology, Italy; [2]University of Genova, DIBRIS, Genova Ge, Italy,; [3]Unit of Child Neuropsychiatrist, Pavia, Italy;

The visual experience is fundamental for the development of neural networks. The information decodes during wake were reprocessed during sleep, therefore the absence of one sensory input influences both waking and sleep neural processing with implications for brain maturation. During wake, vision is associated with the occipital EEG alpha activity and its maturation is a vision-dependent mechanism. Indeed, the alpha activity is absent in blind adults, while when this activity diverges between sighted and blind individuals during the development is still unclear. We consider the spectral power of resting-state EEG between 0 and 11 years in blind and sighted children to reconstruct the developmental trajectory of alpha activity. Then we consider its association with motor dysfunction indices. Blind infants/toddlers show posterior alpha activity although weaker and slower maturation compared to sighted controls. The first great differentiation between groups occurs between 3 - 6 years. Starting from this period, reduced occipital alpha activity increases the probability of motor dysfunctions in blind subjects. During sleep, the plastic changes of the ongoing sleep mechanisms in the absence of vision remain unknown. Specifically, the development of sleep structure in blind individuals is poorly investigated. We consider naps macrostructure (sleep statistics and spectrograms of sigma and delta bands) and microstructure (sleep spindles and slow-waves) in blind and sighted children aged 0 to 6 years. Sighted children show a stronger sigma activity and denser fast spindles than blind peers and only in the sighted children decreased with age, suggesting a difference in the maturation and synaptic pruning processes of the sensorimotor information between groups. The maturation of slow waves activity mainly diverges for morphology and topography. These results show that visual experience mediates the neural mechanisms underlying alpha activity during wake in the earliest life, and notable differences in sleep structures development.

2:30pm - 2:45pm

Visuo-haptic processing of unfamiliar shapes: comparing children and adults

Alahmad, Furat[1]; Rau, Anne[2]; Wallraven, Christian[1]
[1]Korea University, Korea, Republic of (South Korea); [2]Eberhard Karls University of Tuebingen, Tuebingen, Germany;

The question of how our sensory perception abilities develop has been an active area of research, establishing trajectories of development from infancy that last well into late childhood and even adolescence. In this context, several studies have established changes in sensory processing of vision and touch around the age of 8 to 9 years. In this experiment, we explored the visual and haptic perceptual development of elementary school children of ages 6-11 in similarity-rating tasks of unfamiliar objects and compared their performance to adults. The participants were presented with parametrically-defined objects to be explored haptically and visually in separate groups for both children and adults. Our results showed that the raw similarity ratings of the children had more variability compared to adults. A detailed multidimensional scaling analysis revealed that the reconstructed perceptual space of the adult haptic group was significantly closer to the parameter space compared to the children group, whereas both groups' visual perceptual space was similarly well reconstructed. Beyond this, however, we found no clear evidence for an age effect in either modality within the children group. These results suggest that haptic processing of unfamiliar, abstract shapes may continue to develop beyond the age of 11 years later into adolescence.

Wednesday Afternoon Talks

3:15pm - 4:45pm

Vestibular / Self-Motion

3:15pm - 3:30pm

Multisensory Integration of Audio-Visual Motion Cues during Active Self-Movement

Gallagher, Maria; Culling, John F.; Freeman, Tom C. A.
Cardiff University, United Kingdom;

When the head and/or eyes move, integration of vision and hearing is complicated as the sensory measurements begin in different coordinate frames. We propose that audio-visual integration in active perceivers is performed in body-centred coordinates: specifically, audio and visual motion cues are separately transformed using self-movement signals, before being integrated as body-centred cues to audio-visual motion. We first tested whether body-centred audio-visual cues were optimally integrated. Participants made left/right judgements of audio, visual, or audio-visual targets during self-generated yaw head rotations. Target speeds were scaled as a percentage of the ongoing head movement. Cue reliability was manipulated by adding an audio and/or visual positional jitter. Estimates of precision and bias from the audio and visual conditions were used to predict optimal performance in the audio-visual condition. According to our model, the self-movement signal is shared between the audio and visual body-centred cues. We therefore measured the noise of the head-movement signal in a separate paradigm, which allowed us to estimate the partial correlation between cues. With this included, the model predicted audio-visual precision and bias well. Our support for a body-centred integration model contrasts with the spatial localisation literature, where auditory signals are first thought to be transformed into eye-centred coordinates before integrating with vision. We tested this hypothesis by investigating whether eye-movement signals influence audio motion judgements. Participants made left/right judgements of audio or visual targets during fixation or smooth pursuit eye movements. Target speed was scaled as a percentage of the pursuit stimulus. We found precision declined during pursuit for visual targets but not auditory targets. Unlike localisation, it therefore appears that auditory motion is not converted into eye-centred coordinates. Taken together, our findings therefore suggest that motion perception in active observers is based on the integration of partially-correlated body-centred signals.

3:30pm - 3:45pm

Vestibular and visual brain areas in the medial cortex of the human brain

Beer, Anton L.; Markus, Becker; Frank, Sebastian M.; Greenlee, Mark W.
Universität Regensburg, Germany;

Self-motion perception involves a network of cortical vestibular and visual brain regions, including the parieto-insular vestibular cortex (PIVC) and the posterior insular cortex (PIC) located in the lateral cortex. In the medial cortex, the cingulate sulcus visual (CSv) area has been found to process visual-vestibular cues. Here, we report evidence suggesting that the visual-vestibular network of the medial cortex extends beyond area CSv. We examined brain activation in the medial cortex of 30 healthy right-handed participants by means of functional magnetic resonance imaging (fMRI) during stimulation with visual motion, caloric vestibular, and thermal cues. We found that area CSv and V6 responded to both visual and vestibular cues but not to thermal cues. In addition, we found a region inferior to CSv within the pericallosal sulcus (vicinity of anterior retrosplenial cortex) that primarily responded to caloric vestibular cues and which was distinct in terms of its location from other known areas of the medial vestibular cortex. This 'pericallosal' vestibular region did not respond to either visual or thermal cues. It was also distinct from another retrosplenial region that responded to visual motion cues. Together, our results suggest that the visual-vestibular network in the medial cortex not only includes areas CSv and V6, but two additional brain regions adjacent to the callosum. These two brain regions exhibit similarities in terms of their locations and responses to visual and vestibular cues with homologue brain regions recently described in non-human primates.

3:45pm - 4:00pm

Pluri-sensory puzzles of Persistent Postural Perceptual Dizziness (PPPD)

Sumner, Petroc[1]; Powell, Georgina[1]; Price, Alice[1]; Gamble, Ryan[1]; Goodwin, Nathan[1]; Loizides, Fernando[1]; Derry-Sumner, Hannah[2]; Rajenderkumar, Deepak[2]; Rushton, Simon[1]
[1]Cardiff University, United Kingdom; [2]University Hospital of Wales, Cardiff, UK;

Our sense of balance occurs through integration of vestibular, visual, and proprioceptive signals. Conflict between these signals (e.g. in virtual reality) can create dizziness or nausea. However, in a puzzling clinical condition disabling dizziness is triggered by visual motion that is unproblematic for most people (e.g. cinema) and often without theoretical cue conflict (e.g. supermarket aisles or walking past a railing / high contrast grating). These patients also commonly experience anxiety, and sometimes even out-of-body or dissociative episodes (feeling 'not there'). The condition is Persistent Postural Perceptual Dizziness (PPPD) and the prevailing explanation is that patients have become over-reliant on vision ('visually dependant') following a vestibular deficit, and are therefore destabilised by complex visual environments and motion. However, this general framework leaves many puzzles unanswered, which we have begun to address: 1) why do some people develop PPPD and some not, following similar vestibular deficit? We found a spectrum of visually-induced dizziness in the healthy population (N=2335), with 10% in the patient severity range, implying a predisposition to disabling PPPD should a vestibular deficit occur. 2) what is the nature of this predisposition? We found correlation with visual discomfort to stationary images that deviate from natural scene statistics (r= 0.46; N=1387), aligning PPPD with the visual discomfort literature; and with sensitivity and aversion in other senses (e.g. to loud noises, strong tastes; r= 0.54; N=1107), suggesting the predisposition is multisensory (it also correlates with migraine, but findings hold in non-migraineurs). 3) What does it mean to be 'visually dependent'? We found little correlation between measures of visual dependence, raising questions about how to define and measure the purported root of PPPD symptoms. The next steps are to unpack the nature of multisensory sensitivity, and to model visual dependence using formal sensory integration frameworks.

4:00pm - 4:15pm

Estimating travel distance differs depending on the direction, but not speed of self-motion

Bansal, Ambika Tara[1]; McManus, Meaghan[2]; Harris, Laurence[1]
[1]York University, Canada; [2]Giessen University, Germany;

Although estimating travel distance is essential to our ability to move and navigate through the world, our distance estimates can be imprecise and inaccurate. When moving to the location of a previously seen target, the further the intended target distance, the more people tend to undershoot its location (Redlick et al., 2001). This phenomenon has been modelled as resulting from a leaky spatial integrator, meaning that these mis-estimations occur because (1) the integration "leaks" the further you move, and (2) there is a gain factor involved in transforming visual motion to travel distance (Lappe et al., 2007). The model has only been tested using forward translational movements, and postulates that perceived travel distance results from integration over distance and is independent of travel speed. Speed effects would imply integration over time as well as space. To test this, we measured participants' (n=13) perceived travel distance over a range of speeds and distances in four different directions (up, down, forward, backward). In terms of gains, we found an effects of direction ($F(3) = 7.519$, $p < 0.001$) and speed ($F(1) = 5.415$, $p = 0.02$), but no two-way interaction ($F(3) = 0.222$, $p = 0.88$). In terms of leak rate, we found an effect of direction ($F(3) = 7.519$, $p < 0.001$), but no effect of speed ($F(1) = 1.892$, $p = 0.17$), or two-way interaction ($F(3) = 0.331$, $p = 0.81$). These findings show that when making these distance estimates, there might be an integration across time as well as space, which requires expanding Lappe's leaky spatial integrator model to include a speed term as well. The effects of direction shows that transforming visual motion into travel distance differs depending on the direction of movement, and that the Lappe model can be applied to movement in these directions as well.

4:15pm - 4:30pm

Greater accuracy and precision in visual-vestibular conflict detection is associated with lower VR sickness

Halow, Savannah Jo; Hamilton, Allie; Folmer, Eelke; MacNeilage, Paul
University of Nevada, Reno, United States of America;

Visual-vestibular conflict during virtual reality (VR) use is thought to cause VR sickness, but the relation between conflict-sensitivity and sickness is poorly understood. We investigated this relationship by manipulating fixation behavior (head/scene-fixed) and retinal stimulus location (RSL, central/peripheral/full) in a 2x3 design during a conflict detection task. We measured sickness via completion of Simulator Sickness Questionnaires and discomfort scores every 3 minutes. During each trial, subjects made yaw head movements of 15-50° over ~1.5 seconds, and fixated on either an environmentally-fixed (scene-fixed) target, or a target fixed relative to their field of view (FOV, head-fixed). We manipulated RSL by reducing FOV to ~40° using a peripheral mask (central), a ~40° scotoma (peripheral), or not at all (full). The visual scene was an optokinetic drum displayed using the HTC Vive Pro Eye. Visual scene motion was manipulated to be slower or faster than the subject's head movement, and subjects reported the direction of conflict on each trial (as with or against head movement, respectively). We fit a psychometric function to the data to find the visual gain (visual/head speed) perceived as stationary (PSE, accuracy) and range of gains compatible with perception of a stationary visual environment (JND, precision). Results show correlations between JND, PSE, and sickness scores. Better precision is associated with better accuracy during conflict detection, and better accuracy and precision are both associated with lower reports of VR sickness. These results are the first to our knowledge to demonstrate an association between conflict detection accuracy, precision, and VR sickness.

4:30pm - 4:45pm

Characterization of head orientation and heading during everyday activity: implications for modeling.

Sinnott, Christian B.[1]; Hausamann, Peter A.[2]; MacNeilage, Paul R.[1]
[1]University of Nevada, Reno, United States of America; [2]Technische Universität München, Germany;

Estimation of head orientation relative to gravity and the direction of linear self-motion (i.e. heading) is necessary for postural control, locomotion, and spatial orientation perception. While estimation is likely constrained by natural stimulus distributions, empirical data describing natural distributions of human head orientation and heading is lacking. Here, we measure head position and velocity over dozens of hours of unprescribed natural activity. Approximately 50 hours of unprescribed natural activity, except for periodic calibration movements, was recorded across 10 subjects using an Intel Realsense T265 tracking camera. Across-subject distributions of head orientation relative to gravity and heading were non-normal. Roll was symmetrical and leptokurtic; pitch was asymmetrical, with an over-representation of downward head pitch and high variance. Heading azimuth was multimodal, with modes at 0° and ± 90°. Heading elevation was unimodal with fat tails and high variance. We used these distributions as priors in Bayesian models aiming to explain perceptual biases in heading and head orientation perception. Free model parameters were constant and signal-dependent noise on orientation and heading estimates, which determined variability on the Bayesian likelihood for each orientation and heading direction. Variability increased linearly or sinusoidally with eccentricity from straight ahead or vertical (for heading or head orientation, respectively). Models were fit by minimizing the residual standard error (RSE) between previously observed perceptual biases and modeled biases. Qualitatively good model fits were obtained for previously observed biases in perception of pitch, roll, visually-perceived eye level (VPEL), heading azimuth, and heading elevation. Generally, predicted biases increased with eccentricity. Additionally, predicted biases were asymmetrical where natural distributions were asymmetrical, e.g. for head pitch, and asymmetry was reflected in previously reported psychophysical data. Goodness of fit was quantified using RSE: these values were 8.346° for roll, 4.847° for pitch, 1.475° for VPEL, 2.775° for heading azimuth, and 8.476° for heading elevation.

Wednesday Afternoon Posters

Wednesday Afternoon Posters

4:45pm - 5:45pm

Cue Combination in Weight Perception

Kristiansen, Olaf; Scheller, Meike; Aston, Stacey J.; Kentridge, Robert W.; Nardini, Marko
Durham University, United Kingdom;

Redundant cues to the same environmental property can be combined for more precise sensory estimates, e.g. combination of visual and haptic cues can improve the perceptual precision of object size. Here, we investigated whether such combination effects also extend to weight perception. In addition to the haptic information gained from lifting an object, weight information can also be gleaned from the object's visual properties like size and density. We hypothesise that compared to the best single cue, precision will be enhanced with both visual and haptic cues. Eleven participants completed a forced choice task in three sensory cue conditions: visual, haptic, or visuo-haptic. Stimuli consisted of nine jars containing different amounts of sand (290 – 390 grams). Participants either viewed the contents of transparent jars (visual cue), lifted opaque jars (haptic cue), or lifted transparent jars (visuo-haptic cue). Each condition contained 64 trials in which participants were presented with two jars and judged whether the second jar was heavier or lighter than the first one. Reliabilities of the two single cues were reasonably well matched (mean sigma = 18.93 grams visual; 17.28 grams haptic). Cue combination predicts that significantly more than half of all participants would show an increase in precision in the visuo-haptic condition compared to their best single cue condition. However, in this preliminary sample, 4 of 11 participants (just under half) did. In this sample, the availability of simultaneous visual and haptic cues did not improve performance in weight perception compared to the best single cue alone. While it could be the case that people do not combine these two information sources efficiently, a larger participant sample will be required to draw firm conclusions. The present, initial data is used to inform a power analysis to determine the sample size needed to reliably detect a combination effect.

Heavy = valuable? The impact of packaging weight on product evaluations and behavioral intentions

Kampfer, Kristina
FH Kufstein Tirol, Austria;

The haptics of product packaging constitutes an integral element in product design; it serves multiple distinct functions and influences consumer response. This research examines how product packaging weight, as a non-diagnostic extrinsic product property, affects consumers' product appraisals. Drawing from existing work on haptic transference, we propose a conceptual framework to explore how weight, a critical element of product packaging, affects product evaluations and behavioral intentions. Specifically, the results of three experimental studies reveal that increased packaging weight can lead to more favorable product evaluations, which manifest in increased purchase intention, recommendation intention, and willingness to pay. Moreover, this research accounts for both intrinsic and extrinsic product properties and applies a multisensory approach. Thus, we investigate boundary conditions and show that intrinsic sensory product properties, such as smell, moderate the effect of packaging weight on product evaluations. This research demonstrates that consumers' subjective perceptions of olfactory fragrance weight moderate the effect of packaging weith on product evaluation. Moreover, the effect also differs contingent on objective olfactory weight as an intrinsic product property. The more sensory weight consumers perceive, the less packaging weight can contribute to more favorable evaluations. We therefore demonstrate sensory weight overload for objective sensory differences in terms of olfactory fragrance weight. The findings of this study shed light on sensation transference effects and operating causal processes. They support the account that a subtle variation in packaging weight as a non-diagnostic extrinsic product property can affect product evaluations and therefore show a subconscious transference effect of haptic packaging properties on behavioral intentions. Beyond, they contribute to a better understanding of the multisensory interplay of intrinsic and extrinsic product properties in consumer response and the mediating processes that operate when processing packaging weight in product evaluations and subsequent behavioral intentions. Moreover, they have important implications for packaging design decisions.

How visuomotor predictability affects tactile suppression: Slicing objects with a sword in virtual reality

McManus, Meaghan; Schütz, Immo; Voudouris, Dimitris; Fiehler, Katja
Justus Liebig University Giessen, Germany;

When we move we generate predictions about the sensory states of our movement. If the predicted somatosensory consequences match the actual sensory feedback, somatosensory sensitivity is substantially decreased. This is referred to as tactile suppression. Here we investigated how the strength of tactile suppression is modulated by visuomotor predictability. Participants performed an object interaction task in virtual reality. They were asked to cut an approaching rectangular object in half using a virtual sword. In three separate conditions we manipulated the predictability of a change in the object's orientation. As the participant moved to cut the object it (1) always maintained its current (0° or 90°) orientation, (2) always rotated by 90°, or (3) had a 50% chance of rotating. The unpredictable condition caused participants to make unexpected changes to their movement trajectory. To probe tactile suppression, we delivered a vibrotactile stimulus after the change of rotation using the VR controllers. Participants were asked after each trial if they felt a vibration. We hypothesized that unpredictable changes in the object's behaviour would lead to a decrease in suppression compared to predictable changes as the participant would have to attend more to sensory feedback from their hand in order to hit the object. As expected, our results showed tactile suppression during movement compared to rest. In contrast to our hypothesis, the tactile threshold was increased when moving to slice the visually unpredictable object (mean= 0.120, SE= 0.024) compared to the visually predictable and stable object (mean= .032, SE= 0.018)(p= 0.004). It appears that when participants have to interact with a visually unpredictable object they might attend less to their hand leading to an increase in the detection threshold compared to a visually predictable object. This suggests an interaction between predictive and attentional mechanisms in dynamic tasks.

Viewed touch influences tactile detection by altering decision criterion

Nair, Anupama; Medina, Jared
University of Delaware, United States of America;

Our tactile perception is shaped not only by somatosensory input but also by concurrent visual information. Studies that have investigated the effect of viewing touch on tactile perceptual processing have found higher detection rates of tactile stimuli when paired with viewed touch relative to a control visual stimulus. Furthermore, neuroimaging evidence has shown that viewing touch activates S1 and S2 that are also activated during tactile perception. Therefore, some have proposed a vicarious tactile system that activates somatosensory areas when viewing touch. Given higher tactile detection rates with viewed touch versus control conditions, it has been hypothesized that vicarious activity enhances perception of the tactile stimulus. However, an alternative explanation is that viewing touch does not alter the tactile perceptual signal but simply makes the observer more liberal in their decision to report a tactile stimulus relative to not viewing touch. Such a liberal bias would also result in increased accuracy in a tactile detection task, confounding effects on perception with those on decision-making. To disambiguate between the two explanations, we examined the effect of viewed touch on tactile sensitivity and decision criterion using signal detection theory. In three experiments, participants engaged in a tactile detection task while viewing a hand being touched by a human finger, a red dot or not touched or approached at all. We found that viewing touch by the human finger led to a consistent liberal shift in the criterion relative to not viewing touch, while we failed to find a consistent effect of viewed touch on tactile sensitivity. These findings provide evidence that viewing touch influences tactile performance by altering some mechanism underlying the tactile decision process rather than through a modification of the tactile perceptual signal.

Cognitive Impacts on the Crossed-Hands Deficit: Examining the Influence of Visual Imagery and Attention

Lorentz, Lisa; Unwalla, Kaian; Shore, David I.
McMaster University, Canada;

Localizing tactile stimuli in the world requires information from an internal, somatotopically-based reference frame, as well as information from an external, visually-based reference frame. Conflict across information in these two reference frames, such as when the arms are crossed over the body midline, leads to a large localization deficit. Although this crossed-hands deficit (CHD) is robust, decreasing conflict between the two reference frames has been shown to reduce the magnitude of the deficit (e.g., Cadieux & Shore, 2013, *Multisensory Research*). Our recent work (Lorentz, Unwalla, & Shore, 2018, *IMRF)* demonstrates that visually imagining crossed arms as uncrossed reduces the CHD, presumably by bringing visual information in the external reference frame back into alignment with somatotopic information in the internal reference frame. The present study builds on this imagery result by replicating the effect with appropriate control conditions. In addition, we examine the contribution of breadth of attentional focus and dividing attention to the magnitude of the CHD. Results are discussed in relation to the conflict model of the CHD.

Wednesday Afternoon Posters

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4:45pm - 5:45pm

Perceptual size-weight illusion in haptic augmented virtual reality

Günter, Clara[1,2]; Franklin, David[1,2]; Leib, Raz[1]
[1]Technical University of Munich, Germany; [2]Munich Institute of Robotics and Machine Intelligence, Technical University of Munich, Germany;

During object manipulation, we use visual, kinesthetic and tactile information to estimate different mechanical properties which characterize the object. For example, while lifting an object, we estimate its weight by integrating visual-based weight prediction with force feedback and skin deformation that we experienced during the lift. While we can precisely indicate the types of information which are available for weight estimation, the mechanism for forming this estimation is still unknown.
One way to examine this question is by manipulating the sensory information available for the somatosensory system such as in the case of the size-weight illusion. In this illusion, participants lifting objects of different sizes perceive the smaller of two equally weighted objects to be heavier. Such perceptual bias provides evidence for the characteristics lying at the basis of the computational mechanism of weight estimation. To further reveal characteristics of sensory integration that generate this illusion, we built a haptic augmented virtual reality system that mimics the physical object lifting task while allowing us to investigate the relative contributions of specific feedback modalities as well as the effects of timing of the availability of the respective information. In multiple experiments, participants grasped and lifted two virtual objects and were tasked to report which object they perceived to be heavier. We show that consistent with previous real-world experiments, the size-weight illusion could be elicited, producing a shift in the point of subjective equality (PSE). Furthermore, a control experiment showed no shift in weight perception if reference and control objects were identical in size. Based on these results we propose further experiments that aim to induce perceptual illusions based on the manipulation of tactile information using an integrated skin stretch device.

The Effects of Vision on Static-Touch Coarse Roughness Discrimination

Li, Min[1]; Roberts, Roberta[1]; Di Luca, Massimiliano[1]; Allen, Harriet[2]; Wing, Alan[1]
[1]University of Birmingham, United Kingdom; [2]University of Nottingham, United Kingdom;

The cues available for discerning surface roughness vary with the type of texture (Katz, 1925), with the exploratory movement performed (Lederman and Klatzky, 1996) and with the sense modalities involved. For coarse textures statically in contact with the skin, spatial tactile cues about surface roughness are present, but visual cues should arguably be more informative due to the better spatial acuity of vision. To test whether this is the case, we employed a semi-silvered mirror to modify the roughness of visual and tactile surfaces, independently, while participants believed to be touching the object that they were seeing. Participants compared the tactile sensation of two surfaces either with their eyes closed, with an identical visual roughness, with a discrepant visual roughness or with a non-informative visual projection obtained by adding a blurring filter. All conditions were randomly interspersed. Although subjects with good tactile discrimination performed consistently well in all conditions, results showed that participants with poor tactile discrimination ability improved their performance with informative and, surprisingly, even with non-informative vision. Our finding also indicated that incongruent visual information could bias, but also impaired the discrimination performance for all participants. Our findings suggest that two separate mechanisms are at play during roughness discrimination, one that leads to improved performance through the integration of visual and haptic estimates about roughness, and another that improves discrimination by the mere presence of visual information, even if not informative.

The size-weight illusion still occurs at minimal size and density differences

Pisu, Veronica; Graf, Erich W.; Adams, Wendy J.
University of Southampton, United Kingdom;

In the size-weight illusion (SWI), the smaller of two same-mass, same apparent material objects is perceived as heavier, and vice versa. As visuo-haptic size (volume) and mass cues appear contrasted rather than integrated, the SWI has proved difficult to explain with models taking into account object size and mass (either perceived or expected), and has been labelled as 'anti-Bayesian'. This has been challenged by recent cue-integration models focussing on the role of object density (inferred by size and mass) rather than size in the genesis of the illusion. Additionally, although the SWI magnitude increases with size – or density – difference, few SWI demonstrations have included very small differences in object volume, a range where estimates might be expected to be integrated, rather than contrasted. To this aim, we tested perceived weight for stimuli (cubes) which varied in size (min difference: 175 cm^3), and / or mass (min difference: 25 g), and / or density (min difference: 0.05 g/cm^3). Each stimulus belonged to one of three subsets, corresponding to different volume / mass relationships: 1) Fixed density (mass increased with volume); 2) Decreasing density (same-mass, 'SWI' objects); 3) Increasing density (mass and density increased with volume). In a visuo-haptic task, participants (N = 30) grasped and lifted pairs of cubes, and reported their perceived heaviness via magnitude estimation. Results show that the SWI occurs even at minimal volume / density differences, with object density a good predictor for heaviness estimates even at very small size differences. However, for both non-SWI sets, perceived heaviness is well predicted by object mass alone, with no appreciable contribution of density in the increasing density set. Further analyses model heaviness estimates over object sets to contribute to the understanding of the SWI in the wider framework of heaviness perception.

Visual-tactile integration for Roughness Estimation in Augmented Reality

Filipovica, Maija; Singh, Nishant; Roberts, Roberta; Li, Susan Min; Abdlkarim, Diar; Di Luca, Massimiliano; Wing, Alan Miles
University of Birmingham, United Kingdom;

Literature suggests that texture perception is a multisensory process (Guest & Spence, 2003), and previous studies have manipulated the sensory discrepancy between touch and vision to investigate how multimodal signals are combined to form a unified sensory percept. For example, Lederman et al., (1986) showed that the tactile perception of coarse surfaces is affected by an incongruent visual display. However, it is challenging to provide a conflicting multisensory environment that is convincing and allows the experimental manipulation between vision and touch to be accurate and flexible. This study aims to explore how visual and tactile cues combine for roughness perception in an augmented reality setting. In this experiment, subjects pressed on tactile surfaces for which the visual representation was manipulated in virtual reality (VR). While pressing on the tactile stimuli, subjects saw virtual surfaces with either identical, conflicting, or no spatial detail, in addition to unimodal vision or touch trials. Participants had to rate the roughness of coarse tactile surfaces on a visual-analogue scale in VR. The results showed that perceived tactile roughness was biased by visual representations in VR that were either 10 % more or less rough than the tactile surfaces. When visual display provided no spatial information about the roughness of surfaces, results showed the trend that participants judged the roughness of coarse surfaces rating according to only the tactile estimates. The current findings indicate that visual cues in VR altered the perceived roughness of a tactile surface, and provide evidence for visual-tactile integration in texture perception that extends to augmented reality and virtual environments.

New measures of multisensory integration in reaction times based on relative entropy

Colonius, Hans[1]; Diederich, Adele[2]
[1]Universität Oldenburg, Germany; [2]Jacobs University Bremen, Germany;

Following the definition of *multisensory integration* (MI) as 'the presence of a (statistically) significant change in the response to a cross-modal stimulus complex compared to unimodal stimuli' (Stein et al., *Exp Brain Res*, 2009), this is typically translated into an index of facilitation for reaction times (RT) by subtracting mean bisensory (e.g., visual-auditory) reaction time from the smaller of the unisensory means. After standardization, this results in a value between zero and 100: $FAC = [\min(RT_V, RT_A) - RT_{VA}]/RT_{VA} \times 100$. Although widely used, at least two shortcomings of this index are apparent. (i) It is based only on measures of central tendency (means, medians), whereas effects of higher moments (e.g., variance/noise) on MI are well-known; (ii) it does not take into account effects of probability summation. Here we suggest, first, some elementary properties any quantitative measure of MI in reaction times should possess. Following that, we suggest a class of novel measures of MI that make use of the entire uni- and bisensory RT distributions. It is based on *Kullback-Leibler (KL) divergence* (aka *relative entropy*), a concept that plays an important role in information theory, statistics, and machine learning. To demonstrate, let $g(V,A)$ to be the RT distribution predicted by a model using only information from the unisensory conditions (e.g., independent probability summation model) and let $h(VA)$ be the (observed) bisensory RT distribution. The KL divergence from $g(V,A)$ to $h(VA)$ then measures how much information is missing from a model based on information only from the unisensory conditions in order to predict ("explain") the bisensory integration performance. Behavior of the new measures is demonstrated on empirical data and via simulations including statistical estimation procedures.

Wednesday Afternoon Posters

Wednesday Afternoon Posters

4:45pm - 5:45pm

Signal Detection Theory and multisensory coupling

van Dam, Loes C.J.[1,2]; May, Keith A.[2]
[1]Technical University of Darmstadt, Germany; [2]University of Essex, UK;

Signal Detection Theory (SDT) describes target present/absent tasks as two distributions: one each for the target-present and target-absent cases. If the variances are equal, the distance between the two distributions, normalised with respect to the width/standard deviation, is what is known as the perceptual sensitivity *d'*. The response criterion *c* identifies a decision boundary relative to an unbiased one midway between the centres of the two distributions. In practice, *d'* and *c* are often calculated from the proportion of hits and false alarms in target detection tasks, and are interpreted as perceptual and decisional factors, respectively. However, a correct interpretation of *d'* and *c* needs to consider the underlying distributions.
To illustrate this, here we consider, from a theoretical perspective, the case of multisensory coupling in which the target-present and target-absent distributions both tend to change in position and variance when going from unisensory to multisensory conditions. We consider the case where participants judged the presence or absence of a multisensory discrepancy (e.g., Choe et al., 1975, Perception & Psychophysics). The posterior distributions from the coupling model provided the account for perceptual changes in the multisensory estimates. We furthermore varied physical decision boundaries by shifting them within the estimate space. The outcomes of the model, were then used to calculate *d'* and *c* in the classical manner from the proportions of hits and false alarms. We observed that perceptual changes from multisensory coupling led to changes in both *d'* and *c*. Changing the physical decision boundaries likewise led to changes in both *d'* and *c* albeit to different magnitudes. This illustrates the point that care should be taken when interpreting *d'* and *c* in terms of perceptual versus decisional aspects of a task, and when using these measures one should carefully consider what is happening to the underlying distributions.

Visually guided redirection of reaching actions reveals an enhanced efficiency of online motor corrections towards the body midline

Maselli, Antonella[1,2]; Ofek, Eyal[1]; Cohn, Brian[1,3]; Ken Hinckley, Ken[1]; Gonzalez Franco, Mar[1]
[1]Microsoft Research; [2]Institute of Cognitive Sciences and Technologies, CNR; [3]University of Southern California;

Reaching objects in a dynamic environment requires fast online corrections that compensate for sudden object shifts or postural changes. Previous studies revealed the key role of visually monitoring the hand-to-target distance throughout action execution: if the apparent location of the target or the hand is altered using prisms or virtual displays, corrections are automatically operated in a way that minimize the visual apparent hand-to-object distance, in spite of the visuo-proprioceptive conflicts. Researchers in virtual reality capitalized on this evidence for smoothly redirect reaching actions of the users towards a pre-established location (e.g., to enhance the flexibility of passive haptics). Here we present results from an immersive virtual experiment in which action redirection was adopted to investigate how the efficiency of online corrections depends on sensorimotor asymmetries associated with space perception, brain lateralization, and biomechanical constraints. Participants performed reaching actions while the virtual hand was progressively displaced from the real hand so to trigger online corrections that redirect the action. The efficiency and the degree of awareness of the ensuing motor corrections were taken as assessment variables. The visual displacement of the virtual hand was controlled ad-hoc in a way that allowed us to systematically manipulate the total amount of the redirection, the region of space in which the action unfolded, and the direction of online corrections. Results revealed more efficient visuo-motor corrections for actions redirected towards, rather than away from, the body midline. The effect is independent on the reaching hand and the hemispace of action, making explanations associated with laterality effects and biomechanical constraints unconvincing. More plausible, our results may find an explanation in the finer sensorimotor representations characterizing the space proximal to the body-center, where high-value functional actions, like fine manipulative skills and self-defense, typically take place.

CatchU: A Novel Visual-Somatosensory Integration Tool for Assessing Fall Risk

Mahoney, Jeannette R.[1]; George, Claudene[1,2]; Verghese, Joe[1,2]
[1]Department of Neurology, Division of Cognitive & Motor Aging, Albert Einstein College of Medicine; [2]Department of Medicine, Division of Geriatrics, Albert Einstein College of Medicine;

While multisensory integration effects have been measured across a wide array of populations using various sensory combinations and different neuroscience approaches, multisensory integration tests have not been systematically implemented in clinical settings. We recently developed a step-by-step protocol for administering and calculating multisensory integration effects to facilitate innovative and novel translational research across diverse clinical populations and age-ranges. Our previous research has linked the magnitude of visual-somatosensory integration (measured behaviorally using simple reaction time tasks) to important cognitive (attention) and motor (balance, gait, and falls) outcomes in aging. In recognizing that patients with severe medical conditions and/or mobility limitations often have trouble traveling to research facilities or joining time-demanding research protocols, we deemed it necessary for patients to be able to benefit from multisensory testing in the clinic. Using an established protocol and methodology, we developed a multisensory falls-screening tool called CatchU™ (an iPhone app) to quantify multisensory integration performance in clinical practice that is currently undergoing validation studies. Our goal is to facilitate the identification of patients who are at increased risk of falls and to promote physician-initiated falls counseling during clinical visits (e.g., annual wellness, sick, or follow-up visits). The impetus for creating CatchU™…Before You Fall was to raise falls-awareness and foster physician efforts to alleviate disability, promote independence, and increase quality of life for our seniors.

Intertrial tendon vibration but not agonist muscle fatigue affects visual-proprioceptive sensory weighting during goal-directed movement

Manzone, Damian Matricciano[1]; Rudecki, Julia[2]; Tremblay, Luc[1]
[1]Faculty of Kinesiology and Physical Education, University of Toronto; [2]Physical Therapy, University of Toronto;

While it is important to be physically active, little attention has been given to the how we combine and integrate sensory information (i.e., sensory weighting) during and after a bout of physical activity. Exercise-induced muscle fatigue can lead to perceptual biases during unimodal proprioceptive tasks, although there is mixed evidence supporting a modulation of perceptual variability. For example, increased matching bias and variability were evident during an active limb matching task (Tsay et al, 2012), while only an increased bias without an associated increased variability was evident during a passive limb localization task after exercise-induced muscle fatigue (Sadler & Cressman, 2019). The current study extended this work by exploring multisensory weighting during movement before and after a bout of eccentric upper limb exercise (Exp 1). This muscle fatigue protocol was compared to an intertrial tendon vibration method (Exp 2), which has been shown to increase upper-limb matching and reaching trajectory variability (Goodman & Tremblay, 2018). Also, an imperceptible visual proprioceptive mismatch between the participant's limb starting position and associated cursor was employed to assess sensory weighing (see Sarlegna & Sainburg, 2007). This method determines to which extent participants relied on the proprioceptive or visual starting position to complete their aiming movements. In Experiment 1 (n=14), participants performed aiming movements before and after a bout of eccentric exercise targeting their agonist (biceps strength reduction: M = 29%, SD = 17%). In Experiment 2 (n=10), participants were exposed to agonist-antagonist tendon vibration (5 seconds) prior to starting each trial. While there was no difference in visual-proprioceptive weighting before and after the bout of eccentric exercise, intertrial tendon vibration led to a decrease in proprioceptive weighting compared to no vibration trials. Overall, these results indicate that intertrial vibration can alter sensory weighting of upper-limb reaches, while muscle fatigue may not.

Motor adaptation affects sensory processing of numerosity directly: evidence from reaction times and confidence

Maldonado Moscoso, Paula Andrea[1]; Cicchini, Guido Marco[2]; Arrighi, Roberto[1]; Burr, David Charles[1,2]
[1]Univeristy of Florence, Italy; [2]Institute of Neuroscience, National Research Council, Pisa, Italy;

Like most perceptual attributes, the perception of numerosity is susceptible to adaptation, both to prolonged viewing of spatial arrays and to repeated motor actions like hand-tapping. However, it is possible that adaptation may reflect response biases rather than actual modification of sensory processing. To disentangle these two possibilities, we studied the effects of visual and motor adaptation on visual numerosity perception while also measuring confidence and reaction-times. We replicated previous studies to show that both sensory and motor adaptation robustly distort numerosity estimates of visual stimuli, by 27% and 14% respectively. Importantly, in both cases, the shifts in perceived numerosity were accompanied by similar shifts in confidence and reaction-time distributions. After adaptation, maximum uncertainty and slowest response-times occurred at the point of subjective (rather than physical) equality of the matching task, suggesting that both visual and motor adaptation acts directly on the sensory representation of numerosity, before the decisional processes. These results reinforce evidence for shared mechanisms that encode the quantity of both internally and externally generated events, and advance a useful general technique to test whether contextual effects like adaptation and serial dependence really affect sensory processing.

Wednesday Afternoon Posters

Wednesday Afternoon Posters

4:45pm - 5:45pm

The Effects of Multiple Physical Factors on Creative Thinking, A Field Study

Augustin, Sally Jean[1]; Milota, Cynthia[2]
[1]Design With Science; Research Design Connections; University of California, BerkeleyUnited States of America; [2]Ware Malcomb;

Neuroscientists have comprehensively assessed how design can support creative thinking, most often in studies that detail the effects of a single physical factor. Creativity-linked design elements identified include color (surface and light), visual complexity, plants in view, natural light, visible wood grain, aesthetic factors, soundscapes, comfortable environmental control, audio and visual distractions, ceiling height, opportunities for movement, access to needed tools/task support, nonverbal messages sent by a space, and chance for cognitive restoration, for example (e.g., Batey, Hughes, Crick, and Toader, 2021; Studente, Seppala and Sadowska, 2016; Weitbrecht, Barwolff, Lischke, and Junger, 2015). For the study reported here, multiple factors linked by previous research studies to enhanced creative performance were investigated simultaneously in a real-world setting. Study participants first completed a task that assessed their individual creativity at a particular moment in time (Green, Spiegel, Giangrande, Weinberger, Gallagher, and Turkeltaub, 2017). Then the study participants categorized/described the components of the physical environment in which they did that task using the criteria noted above (e.g., surface colors). Findings confirmed many hypothesized consistencies between aspects of the physical environment previously identified as supporting creative thinking and the design of spaces where participants whose creativity test scores were among the highest 25% ("highest scorers") completed the creativity task. Data from the highest scorers indicated that, compared with other participants, they were more likely to have answered the creativity test questions in spaces with, for example: • Surface colors with saturation and brightness levels that support cognitive work• Possible natural light • Plants in view • Visible woodgrain • Nature sounds audible • More, comfortable environmental control • Ceiling heights linked to enhanced creativity. And that were perceived to support mental work. Designers can apply the information derived by this study to develop environments that support creative thinking/problem solving and researchers can also use findings to better understand data collected.

Immersion in multisensory virtual environments changes willingness to pay

Tang, Jiawen[1]; Ward, Ryan[1]; Meyer, Georg[2]
[1]University of Liverpool, United Kingdom; [2]Virtual Engineering Centre;

Optimal pricing of products depends on understanding the target market's willingness to pay (WTP). Standard techniques (van Westendorp, Gabor Granger) to measure WTP are routinely applied in laboratory settings. Consumer decisions depend on the specific environment which can be simulated in virtual reality (e.g. Lichterm, M*öslein, Sarstedt, & Scharf,* Food Quality and Preference, 89:104138, 2021). The aim of this study is to evaluate the effect of placing 'consumers' in different multisensory virtual environments on their willingness to pay (WTP). In the first experiment, we tested participants using a modified Gabor-Granger technique in three virtual environments, a luxury shop, a supermarket, and a real lab environment on two products using a repeated-measures, factorial design. The behavioural data shows significant main effects for product type and environment. Participants report higher WTP in the luxury environment than in the supermarket. Interestingly, the van Westendorp 'indifference price point' in the (neutral) laboratory environment was consistently between the two VR experiences. The presence of ambient sounds and odours affects decision-making processes (Ward, Wuerger, & Marshall, Journal of Perceptual Imaging, 4:2, 2021). In a second experiment, we focussed on the effect of auditory and olfactory valence on WTP. Our results demonstrate the difference between price assignments in semantically congruent and incongruent virtual environments with olfactory ambient information. The findings suggest that multisensory virtual environments elicit differential WTP measures, which are consistent with theoretical expectations. In addition to the primary utility of testing new products in appropriate environments, we see a secondary application in the design and validation of shopping experiences that are best suited for specific products.

Quantifying Self-Motion Sensations Induced by Artificial Vestibular Stimulation

Ferrè, Elisa Raffaella[3]; Gallagher, Maria[1]; Romano, Fausto[2]; Bockisch, Chris[2]; Bertolini, Giovanni[4]
[1]Cardiff University; [2]Department of Neurology, University Hospital Zurich; [3]Birkbeck University of London; [4]University of Applied Sciences and Arts Northwestern Switzerland;

The vestibular system provides a comprehensive estimate of self-motion in 3D space. Galvanic Vestibular Stimulation (GVS) is widely used to artificially activate the vestibular organs which then triggers a clear virtual sensation of rotation on the roll axis. Postural responses to GVS have been largely investigated, however quantifying the perceived virtual rotation vector has not been fully realised. Critically, the self-motion sensation triggered by GVS could prove useful in other contexts, including sensory substitution in vestibular-loss patients and immersive Virtual Reality environments. Here we aimed to quantify the perceived virtual rotation vector elicited by bipolar GVS (Left-Anodal/Right-Cathodal = LGVS; Right-Anodal/Left-Cathodal = RGVS) using a 3D turntable. Subjects lay supine, and on each trial the turntable rotated about the earth-vertical (naso-occipital) axis clockwise or anticlockwise. During the rotation, GVS inducing a virtual roll-rotation in the opposite direction to the turntable sensations was delivered. Participants were asked to report their perceived direction of motion. The QUEST algorithm was used to select the velocity of the turntable, culminating in an estimation of the velocity in degrees at which GVS and the turntable rotation sensations were equivalent. Participants perceived a virtual roll rotation towards the cathode of approximately 2 deg/s velocity for 1mA GVS (LGVS = 2.05±0.48; RGVS = -1.50±0.21) and 6 deg/s velocity for 2.5mA GVS (LGVS = 5.88±1.07; RGVS = -6.47±0.96) . These estimates were based purely on perceptual judgements, in the absence of any motor or postural responses to GVS and in a head orientation where the GVS-induced roll sensation did not interact with the perceived direction of gravity. Importantly, the observed values were also stable across repetitions within subjects. Our results can therefore reliably quantify the physical correspondence of GVS induced sensations.

Unimodal Weights in Bimodal Perception: Influence of intermodal differences in stimulus reliability and task induced saccades on crossmodal bias

Rieger, Alisa[1]; Quinton, Jean-Charles[3]; Lefort, Mathieu[2]; Guyader, Nathalie[3]; Chauvin, Alan[3]; Avillac, Marie[1]
[1]CRNL, France; [2]Université Claude Bernard Lyon 1; [3]Université Grenoble Alpes;

Most multisensory experiments are conducted in artificial conditions, i.e. in which gaze is constrained. This does not reflect the inherently active nature of perception. Consequently, we were interested in effects of gaze movement on crossmodal bias in the ventriloquism paradigm, which describes the degree in which the localization of an auditory target stimulus is influenced by a visual conflicting stimulus. 19 participants, were instructed to localize auditory stimuli (pink noise bursts) with a mouse click whilst spatially coherent or incoherent visual stimuli (gabor patches) were displayed. We used a 2 x 2 x 3 x 2 within subject design and manipulated (1) spatial separation between auditory and visual stimulus (±6°, ±12°), (2) direction of separation (nasal, temporal), (3) auditory stimulus reliability (high, medium, low) and (4) perception mode (fixation, saccade), by instructing the participants to either keep gaze on the fixation cross or move gaze towards the perceived location of the auditory stimulus. We measured crossmodal bias of the manual localization response. For trials with saccade we additionally measured crossmodal bias of the fixation response with an eyetracking system. The results confirmed the previously reported effect of higher crossmodal bias at lower stimulus separation ($p < .001$, $d = 0.15$). For the manual response but not for the fixation response, an effect of higher crossmodal bias for separation in nasal, than in temporal direction was found ($p = .002$, $d = 0.14$). No effect of reliability and perception mode was found. Discrepancies between manual and fixation bias might be explained by different processes being reflected in them: Fixation bias might refelect intuitiv perception and manual bias might reflect memory and judgement in addition to perception.

A methodology for creating consonant symphonies by integrating all senses

Pantidos, Constantinos George
BRAND AVIATORS, United Kingdom;

The causes of our behavior are rooted in human dispositions that have helped us survive and thrive. Nature has established an array of systems in our brain and body and made their satisfaction intrinsically gratifying. Our feelings reflect our neural experience. As abundant and varied as our emotions are, they all stem from 12 Fundamental Human Motives, which are triggered by equivalent systems and operations in our brain. Society and culture, far from denying our biological origins, tend to exaggerate them. In our search to integrate everything in our environment, our mind forms configurations, groups with internal correspondences and structural equivalents. These mould and shape hierarchies of meaning and rhythms into a type of coherent language, the source code of our behaviour. The source language functions as a process for integrating the world. Everything around us must make sense according to its structures. In my research, I observed these patterns projected by the brain onto colors, sounds, scents, flavors and materials which I have studied revealing for the first time their underlying connections. The brain synthesizes the information it receives from various sensory channels holistically in order to optimize its response. A metanalysis of almost 5000 scientific papers, books and articles researching the motives behind 200 universal categories of products, services and expressive media that took more than 11 years to complete, helped capture our Fundamental Human Motives at the deepest layers of their deployment, from their biological necessity to the rich hierarchy of inherent concepts they infuse into our everyday life. A book was published based on the research entitled "Living Brands, How Biology and Neuroscience Shape Consumer Behaviour and Brand Desirability" (Lid Publishing, London, 2018).

Wednesday Afternoon Posters

Wednesday Afternoon Posters

4:45pm - 5:45pm

Assessing Cortical Hyperresponsivity and Habituation in Migraine, according to Age and Disease Severity, using Visual Evoked Potentials during Pattern-Reversal Stimulation

Marti-Marca, Angela[1]; Vilà-Balló, Adriá[1]; Cerdà-Company, Xim[1]; Ikumi, Nara[1]; Torralba, Mireia[2]; Torres-Ferrus, Marta[1]; Caronna, Edoardo[1]; Gallardo, Victor J[1]; de la Torre, Anna[1]; Alpuente, Alicia[1]; Soto-Faraco, Salvador[2,3]; Pozo-Rosich, Patricia[1]

[1]Vall d'Hebron Research Institute; [2]Universitat Pompeu Fabra; [3]Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona, Spain;

Introduction: Migraine is a cyclic, neurosensory disorder characterised by debilitating paroxystic, recurrent headache and altered sensory processing. A lack of habituation and a cortical hyperresponsivity between attacks (interictal) have been inconsistently described. These sensory processing alterations are frequently measured with visual evoked potentials using Pattern-Reversal stimulation (PR-VEPs). Our goal was to test whether hyperresponsiveness and a habituation deficit are characteristic of migraine interictally and whether published inconsistencies could be attributed to age or disease severity. **Method:** Two experiments were carried out: (1) 18 young patients (22.8±1.89 years) with low-frequency episodic migraine (3.4±3.35 headache days/month) and 27 matched controls (21.8±2.03 years); and (2) 16 middle-aged patients (41.8±9.21 years) with high-frequency episodic migraine (12.4±4.30 headache days/month) and 29 matched controls (39.2±8.84years), where participants completed the Sensory Perception Quotient (SPQ) questionnaire and we recorded interictal PR-VEPs. Peak-to-Peak amplitudes of P1-N1 were obtained and analysed with linear mixed models considering Block (100 trials/Block) or Trial (all trials) and Group. Habituation was defined as a decrease of P1-N1 across Blocks/Trials and hyperresponsivity as a Group difference in P1-N1 Peak-to-Peak amplitude. **Results:** Patients reported increased sensitivity to visual stimuli on the SPQ ((1)p=0.010 (2)p=0.017) compared to controls. Regarding P1-N1, there were no significant main effects of Group in either (1) or (2), ruling out cortical hyperresponsivity. Significant interactions between Block x Group ((1)p<0.012 (2)p=0.005) and Trial x Group ((1) and (2)p<0.0001) were observed and post hoc tests indicated habituation in patients, regardless of age and headache frequency ((1) and (2)p<0.0001), and controls ((1)p=0.001 (2)p<0.0001). Patients also showed a sharper habituation slope than controls in both experiments ((1)p=0.0001 (2)p<0.0001). **Conclusion:** We did not find a deficit of interictal habituation or cortical hyperresponsivity using PR-VEPs and this did not vary according to age or disease severity in episodic migraine. Our findings contradict patients' perceptions and some published evidence.

Bilateral cochlear implants enable audio-visual attention orienting

Valzolgher, Chiara[1,2]; Farnè, Alessandro[2,4,1]; Truy, Eric[2,3]; Pavani, Francesco[1,2]

[1]University of Trento, Italy; [2]Lyon Neuroscience Research Center, France; [3]Hospices Civils de Lyon, France; [4]Neuro-immersion, Lyon, France;

In people with profound deafness, sound localisation can be partially restored through cochlear implants (CI), with better spatial hearing skills for bilateral than unilateral CI. Here we asked if this spatial hearing recovery impacts beyond auditory processing alone, affecting also the mechanisms for orienting attention across the senses. We tested bilateral CI and unilateral CI users in an audio-visual attention-orienting task and in a sound localization task. For comparison, we also recruited a group of normal hearing (NH) participants, tested in binaural and monaural listening conditions (one ear plugged). Results showed that audio-visual orienting skills of bilateral CI users were comparable to those of binaural NH listeners, and significantly better compared to those of unilateral CI users and monaural NH listeners. These findings matched the pattern of sound localization skills observed in the same groups, and in unilateral CI users we found a relation between their spatial hearing skills and audio-visual orienting abilities. These novel results show that bilateral CI enables audio-visual attention orienting skills better than unilateral CI, thus promoting better recovery of interactions with the multisensory environment. In other words, our study demonstrated that restoring spatial hearing though bilateral CI has consequences for multisensory experience and attentional orienting. These findings extend the benefits related to bilateral implantation beyond spatial hearing and speech comprehension, and they provide insights for future research.

Bouncing or streaming: Crossmodal interaction of audiovisual events by eye tracking

Jin, Yingxiao; Chen, Lihan

School of Psychological and Cognitive Science, Peking University, China;

Previous measures of 'bouncing vs. streaming' illusion mainly relied on subjective reports, and the research evidence is weak to distinguish the perceptual vs. decisional factors in driving this illusion. In current study we aimed to develop more objective paradigms, to explore the signature of 'bouncing' vs. 'streaming' in terms of eye movement parameters, as well as the correspondence between the eye metrics and the reported percepts. In the main experiment, participants tracked one of the two moving discs (with identical properties). When the moving two discs disappeared, they were prompted to make a quick decision of the orientation (upward vs. downward) for a Landolt C (lasting 80 ms), presented either on the left or right side of the screen. Then participants were also asked to judge the type of the discs' motion (bouncing or streaming) by pressing specified key. In a control experiment, only brief and static discs were given and immediately participants received Landolt C test as did in the main experiment. The other timing parameters were keep consistent with those in the main experiment. Comparing to the sound-absent condition, we observed larger self-report bouncing rate in sound-present condition. Corresponding to eye tracking data, the reaction time was shorter, and the correct rate was higher when the visual tracking (preparation of) direction (leftward or rightward) of the subjects coincided with the location (left or right) of the Landolt C. The results indicated that observers were perceptually genuine to report the Bouncing/Streaming illusion, with congruent eye movement metrics.

How does multisensory training facilitate voice learning?

Zadoorian, Serena; Rosenblum, Lawrence D.

University of California, Riverside, United States of America;

While individuals with normal hearing can learn to recognize voices, those with hearing loss or cochlear implants often have difficulty with this task (Cullington & Zeng, 2011; Vongphoe & Zeng, 2005). Potentially, training could help individuals with this difficulty, especially training that highlights the information making each voice unique. It is known that we can recognize voices by using talker's vocal qualities (e.g., breathiness and fundamental frequency; Bricker & Prazansky, 1976). However, talkers can also be identified from their articulatory style (Remez et al., 1997). Importantly, this talker-specific articulatory information is known to be available auditorily (Remez et al., 1997), visually (lipreading; Rosenblum et al., 2007), and can be shared across modalities (Simmons et al., 2021). In fact, there is evidence that voices presented with talking faces are later recognized better on their own compared to when voices are learned alone (Sheffert & Olson, 2004; von Kriegstein et al., 2008). The present study examined whether face facilitation of voice learning is based on talker-specific articulatory information or non-articulatory face information. Results from our study showed an advantage in voice learning for voices learned with moving (β = 0.57, *SE* = 0.24, *z* = 2.36, *p* = 0.018, *CI*: 0.09-1.04) or static faces (photographs of talkers; β = 0.43, *SE* = 0.24, *z* = 1.78, *p* = 0.076, *CI:* - 0.05-0.90) compared to the voices learned alone. However, presenting voices with videos of isolated talking mouths did not provide an advantage (β = -0.02, *SE* = 0.24, *z* = - 0.08, *p* = 0.936, *CI:* -0.50-0.46), which could suggest that cross-modal talker-specific articulatory information is not sufficient for facilitation. However, a follow-up study is using the point-light technique to isolate the articulatory information available beyond the mouth to determine whether voice facilitation can be based on cross-modal articulatory style information.

Influence of gravitoinertial cues on the perception of looming auditory stimuli

TAFFOU, Marine[1]; VIAUD-DELMON, Isabelle[2]; HARTNAGEL, David[1]

[1]Institut de Recherche Biomédicale des Armées, France; [2]CNRS, Ircam, Sorbonne Université, Ministère de la Culture, STMS, France;

Sustained linear acceleration induces an illusion of backward tilt and a modification of the perceived visual horizon in the direction of the illusion. Yet, it is not clear if sustained linear acceleration influences also spatial auditory perception. As being supine modifies the perceived size of visual objects and the size of defensive peripersonal space, we hypothesized that the perceived distance of auditory objects would be influenced by the change of the gravitoinertial force (GiF) during sustained linear acceleration. We tested whether a change in the direction and magnitude of the GiF impacts the auditory perception of looming stimuli. Healthy participants (N=24) were blindfolded, seated in a centrifuge and asked to make time-to-collision (TTC) judgments with auditory looming stimuli. The auditory stimuli were processed through binaural rendering, so that the virtual sound sources were approaching participants from the right frontal space at different speeds (from 1.42 to 2.56 $m.s^{-1}$). We examined TTC judgments in 4 different conditions of GiF's magnitude (M) and direction with respect to participants' mid-body axis (D). Participants were either seated either upright without rotation (M=1G; D=aligned; condition 1); tilted backwards without rotation (M=1G; D= at a 33.5° angle; condition 2); upright, facing the centrifuge axis and rotating to reproduce linear acceleration (M=1.2G; D= at a 33.5° angle; condition 3); tilted at 33.5°, facing outward the centrifuge axis and rotating to reproduce linear acceleration (M=1.2G; D=aligned; condition 4). We also collected participants' estimation of their body orientation with respect to the earth-vertical. Participants experienced illusory tilt when exposed to a sustained linear acceleration (condition 3). However, TTC judgments were modified and longer only when participants were tilted backwards in normogravity (condition 2). This suggests that body posture as indicated by otholithic signals but probably also by other extra-vestibular graviceptors modulates perceived auditory TTC in normogravity.

Low-level and automatic facilitation of perception of degraded speech by vision

Nishikawa, Kotomi[1]; Ujiie, Yuta[1,2,3]; Takahashi, Kohske[1,3]

[1]Chukyo University, Japan; [2]Japan Society for the Promotion of Science, Japan; [3]Research and Development Initiative, Chuo University, Japan;

While the degraded speech is hard to understand, visual presentation of matched text dramatically improves the intelligibility of the speech. Thus cross-modal facilitation of the noisy and ambiguous speech perception was evident. In the present study, we investigated the influence of preceding text on the intelligibility of the degraded Japanese speech stimuli. In the experiments, a written word was visually presented for 400 ms, which was followed by a 400 ms blank and a degraded speech that was either matched or non-matched with the text. The participants rated on 8-point scaling how clear they felt the speech was and also answered whether the text and speech were matched. Experiment 1 replicated the previous findings; the preceding text matched with the speech improved the intelligibility of the speech. Furthermore, we found the larger improvement when the participants responded that the text and speech were matched than when they were unmatched. Experiment 2 examined the effect of semantic information by using pseudo words. We found that the written text of the pseudo word could improve the intelligibility of meaningless degraded speech as long as the text and speech are phonologically identical. In Experiment 3, we suppressed the phonological processing of the written word by introducing a dual-task paradigm. The results suggested that even when the phonological processing of the text reading was disturbed by the secondary task, the written text could improve the intelligibility of the degraded speech to the comparable extent as when there was no disturbance. Taken together, the improvement of the intelligibility of the degraded speech would not be mediated by the semantic processing and would not require the dedicated phonological processing of the text reading. Rather, the low-level and automatic processes would underlie the cross-modal facilitation of perceiving degraded speech by visual information.

Wednesday Afternoon Posters

Wednesday Afternoon Posters

4:45pm - 5:45pm

Selective enhancement of parvocellular visual processing by looming sound

Yamasaki, Daiki[1,2]; Nagai, Masayoshi[1]
[1]Ritsumeikan Univerisity, Japan; [2]Japan Society for the Promotion of Science;

Looming sound that rapidly increases in sound intensity is known to enhance various kind of visual perception. Although such auditory enhancement of visual perception caused by looming sound has been observed even in early visual stages including orientation and contrast sensitivity, it remains unclear whether looming sound affects two subcortical pathways serving visual perception, the magnocellular (MC) and/or parvocellular (PC) pathways. Based on previous findings, it is hypothesized that increased excitability of visual cortex, increased arousal, and attentional capture that are induced by looming sound would cause different results. Namely, increased excitability of visual cortex predicts an overall enhancement of visual performance (Romei et al., 2009), increased arousal predicts selective enhancement of the MC processing through activation of the amygdala (Bocanegra & Zeelenberg, 2009), and attentional capture to a visual target predicts selective enhancement of the PC processing (Yeshurun & Sabo, 2012). In the present study, we investigated the effect of looming sound on visual orientation discrimination task for Gabor patches (Experiment 1) and luminance detection task for square pedestals (Experiment 2; e.g., Pokorny, 2011), in which relative contributions of MC and PC processing were manipulated by stimulus parameters. Through both experiments, we consistently found that looming sound improved task performance only with the PC-oriented stimuli, but had no significant effect on the performance with the MC-oriented stimuli. These results indicate that the enhancement of low-level visual perception by looming sound is specific to visual processing of detailed features that is mediated by the parvocellular pathway. Furthermore, the observed selective enhancement of PC processing suggests that the underlying mechanism is attentional capture caused by the sound.

Semantic incongruency in audiovisual object recognition task disrupts patients with schizophrenia less than healthy controls

Ghaneirad, Erfan[1]; Engels, Anna[2]; Bleich, Stefan[1]; Szycik, Gregor[1]
[1]Medial school of Hannover, Germany; [2]Carl von Ossietzky University Oldenburg, Germany;

Multisensory, as opposed to unisensory presentation of stimuli has been found to be beneficial to a number of tasks for healthy individuals, but not as much for patients with schizophrenia. Suggesting impairment in multisensory integration in this group of patients. To our knowledge, no study has investigated these multisensory integration deficits in the context of working memory (WM), a domain highly multisensory and substantially impaired in schizophrenia. **Subjects:** 10 healthy controls (M=31.80, SD=11.33); 12 Patients with diagnosed schizophrenia (M= 34.55, SD= 10.09). Matched on age, education and gender. **Screening:** Structured Clinical Interview DSM-5 (SCID-5-CV & SCID-5-PD). **Continuous recognition task:** Two blocks á 144 trials (72 initial & 72 repeated presentation) with stimuli being sound of common objects. Participants have been instructed to indicate as quickly and as accurately as possible whether the sound was heard for the 1st or 2nd time. Initial stimuli: 50% unisensory and 50% multisensory of which 50% were semantically congruent (SC) and 50% semantically incongruent (SI). Repeated Stimuli: unisensory. **Results:** group comparison for general performance has revealed that Patient's (M=.62, SD=.22) score is sign. lower than controls (M=.85, SD=.07) in terms of accuracy (t=3.22, p=.002, d= 1.34) but not RT. Patients benefit sign. more from SC than healthy controls (F=5.11, p=.035, η^2= .20). A 2x2 mixed ANOVA comparing multisensory gain/cost indices for RT showed Significant group*condition interaction effect (F=13.95, p=.001, η^2= .41) with No sign. group diff. for SC (t=1.19, p=.250), but for SI (t=2.62, p=.016, d=1.13) with patients being faster. **Conclusion**: Patients showed more facilitation effect in congruent multisensory presentation in terms of ACC. Possibly reflecting compensatory and/or ceiling (i.e., statistical) effects. Semantic incongruency in the initial presentation disrupts performance of patients less, in comparison to healthy control. This group difference might possibly reflect diminished cognitive dissonance due to limited multisensory integration in patients.

Sequential modulation of the Cross-modal Congruency effect: the role of target and distractor sensory modality

Mas Casadesus, Anna; Gherri, Elena
University of Edinburgh, United Kingdom;

Sequential analyses of conflict tasks such as the flanker task have shown reduced congruency effects following incongruent trials (i.e. he Gratton effect ; Gratton et al., 1992). According to the Conflict Monitoring Hypothesis (Botvinick et al., 2001), top-down cognitive control is increased following response conflict on incongruent trials, improving performance on a subsequent incongruent trial. Recent studies have shown the presence of the Gratton effect also in cross-modal congruency tasks (CCT) in which a target in one sensory modality is simultaneously presented with a distractor in a different sensory modality. This demonstrates that the combination of crossmodal stimuli presented on the previous trial impacts performance on a subsequent trial. However, it is not known whether the Gratton effect measured in a CCT is shaped by the specific combination of sensory modalities of the different target-distractor pairings. To address this question we asked participants to complete four CCTs in which a visual target was presented simultaneously with either a tactile or an auditory distractor or in which a visual distractor was accompanied by a tactile or an auditory target. Stronger congruency effects were present when vision was task-irrelevant than when it was task-relevant. Importantly, a reduction of the congruency effect following an incongruent trial (i.e. Gratton effect) was observed with visual distractors, but not with visual targets. Thus, visual distractors strongly activated the spatially corresponding response resulting in large congruency effects and leading to an increased top-down control following an incongruent trial. By contrast, tactile and auditory distractors only weakly activated the spatially corresponding response, reducing the need for increased cognitive control after incongruent trials. Together these findings reveal that the cognitive control processes engaged during CCT are strongly dependent on the specific combination of modalities of target and distractor.

The faster it looms, the faster I detect it: Multisensory integration of looming signals within the autistic traits spectrum.

POULAIN, Rachel[1,2]; BATTY, Magali[2]; CAPPE, Céline[1]
[1]University of Toulouse 3, France; [2]University of Toulouse 2, France;

Atypical sensory processing is now considered a diagnostic feature of autism. Although multisensory integration may have cascading effects on the development of higher-level skills such as socio-communicative functioning, there is an evident lack of understanding of how autistic individuals integrate multiple sensory inputs. Multisensory dynamic information may be a more ecological construct than static stimuli, reflecting naturalistic sensory experiences given that our environment involves moving stimulation of more than one sensory modality at a time. Especially, depth movement informs about crucial social (approaching to interact) and non-social (avoiding threats/collisions) content. The autistic characteristics are distributed on a spectrum over clinical and general populations. On this basis, our work aimed at exploring the multisensory integration of depth cues in the autistic personality spectrum, using a go/no go detection task. The autistic profile of 38 participants from the general population was assessed using two questionnaires: The Autism-Spectrum Quotient and the Adolescent/Adult Sensory Profile. Participants performed a detection task of auditory and/or visual depth moving stimuli (looming or receding) at different speeds compared to static stimuli adapted from previous work. The relationship between the responses to the behavioral experiment and the autistic traits was analyzed based on responses accuracy, reaction times, and race model computation. A positive correlation between autistic characteristics and sensory profile was found. Moreover, results provided evidence of over responsiveness to audiovisual looming, exacerbated with a fast speed and a specific integration of fast movements in the high autistic personality. Results are discussed in light of autism theories and support evidence that low-level stages of multisensory integration could operate with different dynamics all along the autistic personality spectrum. These findings extend to the whole autistic spectrum the growing discussion about the subsequential effect of basic perceptual particularities on the development of social abilities.

Tonal music fits with saturated lighting: The perceived fit of music and colored ambient light depends on crossmodally evoked emotions

Hauck, Pia; von Castell, Christoph; Hecht, Heiko
Johannes Gutenberg University Mainz, Germany;

The quality of a concert hall primarily depends on its acoustics. But does visual input have an impact on the musical enjoyment as well? In the present study, we aimed at answering two questions: Does the color of ambient light modulate the perceived quality of the music we listen to? And are certain lighting colors perceived to fit better than others with a given musical piece? We performed three within-subjects experiments. Two pre-experiments were carried out in order to select the stimuli, namely four music pieces differing in tonality and genre, and 14 lighting conditions of varying hue, brightness, and saturation. In the main experiment, we applied a fully-crossed repeated measures design. Participants rated the musical qualities (harmonic, powerful, gloomy, lively) and overall liking of the four music pieces under each of the lighting conditions, as well as the perceived fit of music and lighting for each stimulus combination. Subsequently, participants performed separate ratings for music and lighting on the same Likert-scales and, in addition, on Self-Assessment Manikin-scales measuring the emotional qualities of the respective stimuli. The results showed that music and light which were similarly rated in terms of valence and arousal in the unimodal conditions, were judged to match better when presented together, e.g. tonal (atonal) music was rated to fit better with weakly saturated (highly saturated) lighting colors. Moreover, certain characteristics of the lighting condition were indeed carried over to music. That is, just as red lighting was rated to be more powerful than green and blue lighting, music was rated accordingly as more powerful under red ambient light. We conclude that listening to music is a multisensory process enriched by impressions from the visual domain.

The soundtrack of my body: Implicit body weight distortions in auditory-driven body illusion in subclinical and clinical eating disorders

Tajadura-Jiménez, Ana[1,2]; Crucianelli, Laura[2,3]; Zheng, Rebecca[2]; Cheng, Chloe[2]; Ley-Flores, Judith[1]; Bordá-Más, Mercedes[4]; Bianchi-Berthouze, Nadia[2]; Fotopoulou, Aikaterini[2]
[1]Universidad Carlos III de Madrid, Madrid, Spain; [2]UCL, London, UK; [3]Karolinksa Institute, Stockholm, Sweden; [4]Universidad de Sevilla, Spain;

Body image concerns have been linked to eating disorders (EDs); however, their co-occurrence with body-representation distortions (e.g. body size/weight overestimations) remains debated. Previous studies on multisensory visuo-tactile bodily illusions reported higher ownership over fake hands in people with EDs compared to healthy populations, suggesting stronger influences of external sensory signals in EDs. Here we manipulated body size/weight estimations with a sensorimotor auditory-driven bodily illusion to investigate whether body-representation mechanisms are altered in subclinical/clinical EDs, assuming an overreliance on external (auditory) bodily signals. In this illusion, participants walk while their footstep sounds are altered to seem produced by lighter ('High-Frequency') or heavier ('Low-Frequency') bodies. Consequently, participants represent their body as lighter/slimmer or heavier/wider and adapt their gait, probably to reduce sensory prediction errors. We recruited 58 healthy women and assigned them to 3 groups according to self-reported ED symptomatology (EDS): Low-EDS, Medium-EDS, High-EDS (Experiment 1), and 15 women with Anorexia Nervosa (AN; Experiment 2). We collected self-report and behavioural body-representation measures (body visualization, gait parameters). We predicted an enhanced body-weight illusion (i.e., lightest/slimmest represented body in 'High-' vs 'Low-Frequency') in people with High-EDS and AN in comparison to Low- and Medium-EDS. In Experiment 1, we found group differences in both behavioral measures but not in self-report. Contrary to our predictions, High-EDS participants displayed the longest stride times, typical of heavier bodies, and widest body visualizations in 'High-' vs. 'Low-Frequency'. In contrast, Low-EDS participants showed this behaviour in 'Low-Frequency', as in previous studies with healthy participants. Similarly to High-EDS, AN participants in Experiment 2 represented their body as widest/heaviest in 'High-Frequency'. Our results suggest altered sensorimotor body-representation mechanisms in subclinical/clinical EDs, providing new insights into the multisensory body-representation and opening opportunities for novel diagnostic tools/therapies for people with/at risk of EDs.

Metacognition Distinguishes Congruent and Illusory Multisensory Perceptions

Odegaard, Brian[1]; Kimmet, Faith[1]; Mims, Callie E.[1,2]; Preston, Anya[1]; Westmoreland, Kendra[1]; Lolo, Kiara[1]; Rosario, Nicholas[1]; Pedersen, Samantha[1]; Cardenas, Victoria[1]; Rubiera, Camila[1]; Johnson, Grey[1]; Sans, Addison[1]; Maynes, Randolph[1]
[1]University of Florida, United States of America; [2]University of South Alabama, United States of America;

Many multisensory tasks provide evidence that conditions with physically distinct sensory signals yield the same perceptual reports from human observers. While this behavioral phenomenon is well-established, recent work has noted that much is still unknown about the degree to which metacognitive systems may (or may not) index differences across conditions with identical perceptual reports (DeRoy, Spence, & Noppeney, TICS, 2016). Specifically, if perceptual reports are the same across two conditions in a multisensory task, are confidence judgments for these conditions similar, or different? In this investigation, we probed this question using two well-known multisensory illusions: the McGurk illusion and the sound-induced flash illusion (SIFI). In our McGurk experiments, we showed that when the reported syllable was matched between congruent speech and McGurk speech, confidence was higher for congruent audiovisual syllables, and lower for McGurk syllables. Similarly, in the SIFI task, when the number of reported flashes was matched across conditions, confidence was higher for fully congruent stimuli, and lower for integrated stimuli. Interestingly, in the McGurk task, when reported syllables were matched across conditions with different inferred causal structures (i.e., integrated stimuli produced by a single cause, or segregated stimuli produced by two causes), metacognition failed to distinguish between these two conditions. Together, these results reveal both the capacities and limitations of metacognition's ability to index different computations in multisensory integration: while metacognition successfully distinguishes congruent and illusory (integrated) multisensory perceptions that contain the same perceptual content, it fails to successfully distinguish between integrated and segregated percepts when the reported content is the same. I will discuss how these findings relate to recent discussions of perceptual and causal metamers in multisensory perception.

Thursday Morning Talks

Thursday Talks

8:30am - 9:45am

Room Danube

Body / Action

8:30am - 8:45am

Audiovisual integration during joint action: How does performing a task jointly affect multisensory perception?

Wahn, Basil[1]; Dosso, Jill[2]; Keshava, Ashima[3]; Gearhart, Anika[4]; Rohe, Tim[5]; König, Peter[3]; Sinnett, Scott[4]; Kingstone, Alan[2]

[1]Ruhr-Universität Bochum, Germany; [2]University of British Columbia, Canada; [3]University of Osnabrück, Germany; [4]University of Hawai'i at Mānoa, USA; [5]Universitätsklinikum Tübingen, Germany;

Sensory experiences are a vital aspect of human existence. In everyday life, our senses are flooded with input, constantly picking up multiple unisensory signals at once. These incoming signals are either processed separately or integrated into one unitary percept – a process known as “multisensory integration”. In addition to these (multi)sensory experiences, social experiences shape human life. Yet, the interplay between social and multisensory processes remains largely unexplored. We present a series of studies, investigating how social manipulations (i.e., performing a task jointly) affect audiovisual integration. Pairs of participants were presented with auditory and visual stimuli that might or might not be perceived as belonging to a single event. Each participant in a pair was required to respond to stimuli from one sensory modality only (e.g., visual stimuli only). Relative to conditions in which participants performed their respective tasks alone, we found that performing a task jointly affected audiovisual integration in a spatial congruency task (Wahn, Keshava, Sinnett, Kingstone, & König, 2017) and in the sound-induced flash illusion (Wahn, Rohe, Gearhart, Kingstone, & Sinnett, 2021). Yet, we did not find any effects of performing a task jointly for a motion discrimination task or a temporal order judgment task (Wahn, Dosso, & Kingstone, 2020). Based on the present findings, we suggest that whether social processing affects audiovisual integration depends on two factors: 1) whether crossmodal effects are quantified via response times or response accuracies, and 2) whether tasks require processing stimuli in terms of location, motion, or timing. We conclude that social processes affect multisensory integration, shaping how we perceive sensory stimuli in our (social) world.

8:45am - 9:00am

Contribution assignment in a joint virtual task

Ramundo, Teresa[1,2]; Balestrucci, Priscilla[2]; Moscatelli, Alessandro[3,4]; Ernst, Marc O.[2]

[1]IMT School for Advanced Studies Lucca, Italy; [2]Ulm University, Ulm, Germany; [3]University of Rome “Tor Vergata”, Rome, Italy; [4]Santa Lucia Foundation, Rome, Italy;

We often perform actions whose outcome depends on the successful collaboration with a partner (e.g. dancing, lifting a heavy object). Nevertheless, little is known about how we shape our contribution based on our knowledge of each actor’s characteristics and skills, and how we can attribute errors and successes to ourselves and our partners in situations where both actors are noisy, and the only available information comes from the common outcome of the joint action itself. In a joint virtual throwing task, we tested whether participants were able to estimate the variance associated with the actions of a virtual partner, and attribute the relative contribution to themselves and their partner in order to maximize the success of the team in the task. Participants collaborated with three different simulated players: one with better performance than the participant’s, one with the same, and one with worse. In each collaboration, participants could assign a weight to their own contribution before performing the throwing task. We provided visual feedback on the outcome of the joint action. We hypothesized that, if participants were able to behave optimally in these three conditions, they would set the weight parameter based on the perceived motor noise (variance) of their partner. That is, they would assume more control with a worse partner, and vice versa. Results provided a more complex situation, as two distinct behavioral strategies emerged: one “near-optimal strategy,” in which participants were able to adjust to the second player’s performance, and one “non-optimal strategy,” in which participants discarded the contribution of the second player and took the majority of control regardless of their partner’s ability. Thus, even if information about the variance of the virtual partner was accessible, different participants used it in heterogeneous ways.

9:00am - 9:15am

Full body motor representation in human amygdala

Aggius Vella, Elena; Amedi, Amir

The Baruch Ivcher School of Psychology and the Ruth and Meir Rosental Brain Imaging Center, Reichman University, Herzliya, Israel;

There is no doubt about the involvement of the amygdala in processing emotions, and that emotions are expressed (and read) through universal body (and face) patterns, the so-called emotional body language. However, nobody has yet investigated the direct connection between the amygdala and body movement. This question is even more intriguing, as the limbic region, of which amygdala is a key component, has descending motor pathways and influences the responses of both skeletal muscles and autonomic functions. Studies on monkeys showed that the lateral basal nucleus of the amygdala projects to the rostral cingulate motor cortex (M3), especially in the face representation area. In humans, amygdala is involved in orofacial muscle movements and orthodontic pain. However, it is still unknown if the amygdala is directly involved in body movement, or if it is only recruited in association to emotional content. Due to its involvement in sensory motor perception, mostly with relation to facial areas, we investigated whether the amygdala contains a body motor representation and if it responds to even neutral body movements. To this aim, we adopted 2 different fMRI designs: 1) a cycle design, in which 10 subjects were required to move 20 body parts and 2) a block design in which 6 subjects were required to move 4 body parts. Results show a motor body map inside the amygdala with a significant representation of face, then arms and then legs. The facial preference was found in each subregion of the amygdala defined by the Juelich atlas. The same result was confirmed with the roi glm approach. Our results show a full body motor representation in the amygdala with a marked preference for facial parts. Importantly, our findings suggest that the body motor representation in the amygdala is not only dependent on emotional expression.

9:15am - 9:30am

Extending the Bayesian Causal Inference of Body Ownership Modell Across Time

Schubert, Moritz; Endres, Dominik

University of Marburg, Germany;

Body ownership is the feeling of an object belonging to one's body. Current Bayesian models of body ownership are limited by assuming that the perception of body ownership can be described by a single posterior update, rather than unfolding dynamically in time. We are working on overcoming this limitation. Our model targets the rubber hand illusion (RHI). The rubber hand illusion (RHI) is one of the most popular paradigms to study body ownership. In an RHI experiment, a rubber hand and the hidden real hand of the subject are stroked in synchrony with a brush resulting in the experience of the brush stroke on the rubber hand as well as the a feeling of body ownership over it in a majority of the subjects. In the context of the RHI, body ownership is commonly believed to be arise due to multisensory integration: Vision, because of its higher precision, captures the tactile input and integrates the two on the rubber hand. Samad et al. have modelled the RHI with the Bayesian Causal Inference of body ownership (BCIBO) model. According to the model, if the sensory evidence favors the rubber hand as the common cause of the sensory signals, they are integrated. Because the BCIBO model only updates its posterior once, it is not able to capture the dynamics of a body ownership illusion. To account for this limitation, we have extended the BCIBIO model by temporal dynamics. Our first model runs are promising and show an accumulation of evidence across time and are able to reproduce an onset time of the body ownership illusion that is in agreement with the literature.

9:30am - 9:45am

Holding an object with a tool improves visually guided grasping

Camponogara, Ivan[1]; Farnè, Alessandro[2,3,4]; Volcic, Robert[1]

[1]New York University Abu Dhabi, United Arab Emirates; [2]INSERM; [3]University of Lyon; [4]Hospices Civils de Lyon;

Haptic inputs from the hand holding the object complement visual inputs by providing object’s positional and size information and improve grasping movements. Interestingly, distal objects can be successfully localized also via a handheld tool. However, it is still not clear whether object features sensed with a tool can also guide a contralateral hand grasping. Here we investigate whether the same advantage obtained by holding the object with the hand can be achieved by holding the object with a tool (a grabber). We replicated our previous findings that grasping actions toward objects we see and hold with the hand show smaller grip apertures and larger peak velocities than grasping guided only by vision. Importantly, we found that tool-guided actions exhibited the same grip aperture reduction, but no boost in velocity. To investigate this further, we manipulated the object information available via the tool (position and size versus position only) and we observed that action performance was not hindered by the absence of size information. In addition, we excluded the possibility that the grip aperture reduction was simply due to an interference effect of the force exerted by the hand pressing the tool’s handle by contrasting tool-guided grasping with or without the requirement to enclose the object with the grabber. In sum, our findings support the idea that tools can be effectively used as sensing devices to improve object localization and guide the contralateral hand movement. However, contacting the object with a tool only partially mimics grasping performance achieved by holding the object with the hand, because in the latter case direct comparisons between the postures of the two arms are available, highlighting the role of haptic on-line control.

Thursday Morning Talks

Thursday Talks

8:30am - 9:45am

Room Lago

Tactile

8:30am - 8:45am

Tactile aftereffects as a psychophysical window onto receptive field organization

Azañón, Elena[1,2]; Frisco, Francesca[3]; Hoffmann, Benjamin[2]; Stenner, Max-Philipp[1,2]; Longo, Matthew[4]
[1]Otto von Guericke University Magdeburg; [2]Leibniz Institute for Neurobiology, Magdeburg; [3]University of Milano-Bicocca, Italy; [4]Birkbeck, University of London, UK;

Adaptation aftereffects can reveal how the nervous system encodes sensory features. We have recently demonstrated that the distance between two tactile events is a property of somatosensation susceptible to adaptation. The reported aftereffects shared several characteristics with low-level visual aftereffects, including orientation and location specificity, pointing to a locus of tactile distance representation early in a bottom-hierarchy of somatosensory processing. Here we focus on this location specificity feature, to better characterize the process by which tactile distance aftereffects operate. In a series of experiments, we applied pairs of pointed tactile stimuli separated by defined distances to one adapting skin region, either on the hand, or on one finger, and tested the magnitude of adaptation aftereffects across adjacent skin regions that did, or did not, cross joint boundaries (i.e., the wrist), skin type (glabrous vs hairy) or separate body parts (i.e., the fingers). We found a spatial gradient in the magnitude of adaptation aftereffects, both in the mediolateral and proximodistal hand axes, with stronger adaptation aftereffects in the vicinity of the adapting region. Crossing joint boundaries from hand to wrist did not change the magnitude and extent of this gradient. Interestingly, however, the effect of adaptation did not transfer across fingers, even when adapting and tested skin regions had somatotopically adjacent representations (e.g., little and ring fingers). Similar effects were observed during adaptation to textures. Critically, the observed effects seem to mimic low level anisotropies in cortical maps, and thus, provide further understanding into unknown properties of cortical organization. Tactile aftereffects thus might provide a psychophysical window onto the distribution, organization, and overlap of tactile receptive fields, specifically with respect to anatomical or functional boundaries between body parts and adjacent regions of the skin.

8:45am - 9:00am

The primitive priming sense: an updated functional account of how affective touch facilitates cross-modal processing

Fairhurst, Merle Theresa[1,2]; Croy, Ilona[3]; McGlone, Francis[4]
[1]Bundeswehr University, Munich, Germany; [2]Ludwig Maximilian University, Munich; [3]Technische Universität Dresden, Germany; [4]University of Liverpool, UK;

Affective touch provides us with a means of transmitting and receiving socially-relevant information, with the skin having been described as a social organ that provides a channel for the exchange of that information. As significant departure for the field, we will suggest that although the central function of this proximal sense may be communication, we will discuss the nature of the exchanges that this sense enables. Specifically, we will stress its limited range in terms of both spatial and temporal resolution and describe how this very specific though limited type of communication may be achieved through slow transmitting C-fibres. As a positive proposal, based on both behavioural and neurophysiological evidence, we posit that affective touch serves to prime the system, for example the facilitation of cross-model processing. Specifically, by comparison with the peripheral and central characteristics of olfaction, we will suggest that along with affective touch, these evolutionary old senses tune attention towards further social interaction. With a focus on the key developmental phases of infancy and adolescence, we will then describe how changes in state, that is readiness to communicate through touch, to touch and be touched, varies as a function of experience. With this updated account of the communicative and priming functions of affective touch, we will discuss the relevance of of this special sense to developmental psychology, the study of computer-human-interaction and social cognitive disorders.

9:00am - 9:15am

Overlapping neural representations between touch to self and others in people with high tactile empathy

Smit, Sophie[1]; Moerel, Denise[2]; Zopf, Regine[3]; Rich, Anina[1]
[1]Macquarie University, Australia; [2]The University of Sydney; [3]Jena University Hospital;

We not only infer what other people are experiencing, we sometimes even feel what they feel. This is the case for emotions, but also for physical sensations such as touch or pain. How do these shared tactile experiences arise? It is often proposed that 'tactile empathy' – feeling touch observed on another person's body - relies on overlapping neural representations between self and others. Seeing someone else touched could trigger similar representations in the observer's own tactile system. Variability in the strength of such crossmodal activation might explain why some individuals report consciously feeling touch on their own body when they see someone else being touched whereas others do not. We investigated shared touch representations using multivariate pattern analysis (MVPA) of electroencephalography (EEG) data. A classifier trained on whole-brain neural activation patterns when participants felt touch to their little finger or thumb, was able to predict which finger was touched when participant observed touch to another person's hand. In individuals with high tactile empathy, information cross-generalised between a late tactile and early visual signal, potentially reflecting the activation of a high-level abstract representation of touch location on one's own body when observing touch. Using carefully matched tactile and visual stimuli, we demonstrate for the first time that time-resolved decoding methods are sufficiently sensitive to extract neural signatures regarding the specific location of touch on the hand when it is seen or felt, and that this can be used to test for shared representations between modalities. Because EEG has high temporal resolution, we are not only able to show *that* representational overlap occurs, but also *when* it is present. These results further our understanding phenomena such as mirror-touch synaesthesia and vicarious touch and pain.

9:15am - 9:30am

Coordinate Transforms Mediating Tactile Motion Representations with the Hand

Ahuja, Himanshu[1,2]; Shivkumar, Sabyasachi[1,2]; Fesitritzer, Catalina[2,3]; Haefner, Ralf M.[1,2]; DeAngelis, Gregory C.[1,2]; Gomez-Ramirez, Manuel[1,2]
[1]University of Rochester, USA; [2]University of Rochester, USA; [3]University of Pittsburgh, USA;

Our ability to perceive motion information on the skin is key to manipulating dynamic objects in the environment. Neural mechanisms that generate perception of tactile motion play a key role in haptics by providing sensory feedback signals used to make grasp adjustments (e.g., signaling that an object is slipping). Previous studies show that the brain derives tactile motion representations by integrating object cues that impinge on the skin (e.g., speed, force, direction), a mechanism known as the Full Vector Average model. This model was derived from studies that placed the hand in the same posture. However, haptics is highly dynamic, with objects often touched with the hand placed in different postures. Thus, it is unknown whether and how these representations are modulated by the proprioceptive state of the hand. Further, whether these motion representations can be represented in different reference frames is unknown. Here, we instructed humans to discriminate motion stimuli on the index finger while the hand was placed in different postures. Participants were cued to judge whether the stimulus was moving to the left or right (relative to their sternum), or towards vs. away from their thumb. The data revealed that humans can flexibly represent tactile motion information according to the instructed reference frame. Further, we observed that proprioception systematically modulated perceptual judgements, but only in judgements made relative to the sternum. We also found lower motion discrimination sensitivity (i.e., acuity) in the sternum task, likely reflecting added noise from integrating the proprioceptive and tactile signals. Lastly, we developed a Bayesian generative model that accounts for the motion percepts in different reference frames and postural configurations. These data show that representations of tactile motion are generated by neural circuits that integrate cutaneous and proprioceptive inputs, and are under control of goal-directed cortical signals.

9:30am - 9:45am

Neural correlates of tactile representations in somatotopic and external reference frames

Raigosa-Posada, Luisa M.[1]; Liu, Yuqi[2]; Medina, Jared[1]
[1]University of Delaware, United States of America; [2]Institute of Neuroscience, Chinese Academy of Sciences;

Previous behavioral work has shown that tactile stimuli are represented in both somatotopic and external frames of reference. Processing stimuli in external frames of reference is multisensory, as it involves combining information modalities beyond somatosensation. Our knowledge of the neural correlates of external representations of tactile stimuli is limited. For example, multi-voxel pattern analysis (MVPA) studies of tactile localization have not disambiguated between somatotopic and external reference frames. To examine this, we used MVPA in two fMRI experiments to identify brain regions involved in somatotopic and external tactile processing. Vibrotactile stimuli were presented to two possible somatotopic locations on the hand in two different postures. To examine hand-centered external processing, vibrotactile stimuli were presented to either the index or ring finger of the right hand while the palm was facing up or down (Experiment 1). In Experiment 2, we presented vibrotactile stimuli to either the left or the right index finger while the hands were crossed or uncrossed to examine trunk-centered external processing. Whole-brain MVPA analyses were used to decode activation patterns for somatotopic and external spatial representations. For both experiments, we found typical regions associated with somatotopic processing (contralateral S1, S2, and premotor cortex), with additional somatotopic regions in Experiment 2 (contralateral supramarginal gyrus, SMA). In Experiment 1, we found significant decoding of hand-centered space in contralateral anterior cingulate and surprisingly, in contralateral secondary visual cortex. However, we found no evidence for external trunk-centered processing in Experiment 2. Altogether, our results suggest a visual component relevant to tactile spatial representation in an external, hand-centered representation. We also demonstrate the presence of somatotopic representations of touch in areas beyond primary somatosensory cortex.

Thursday Morning Symposium Talks

Thursday Symposium

10:15am - 11:15am

Room Danube

Temporal Dynamics in Audiovisual Integration

Weiland, Ricarda Florine; **Jertberg, Robert**

Audiovisual integration is optimal when auditory and visual information is presented synchronously. Perfect synchronicity, however, is highly unlikely due to both physical and physiological factors. In this symposium, we will explore different mechanisms that aid audiovisual integration under different temporal dynamics. Additionally, we will investigate how these mechanisms might vary in different populations, such as children and adults, and individuals with or without a diagnosis of Autism Spectrum Disorder (ASD). Ricarda Weiland will present findings on how adults with and without ASD rapidly recalibrate to audiovisual asynchronies and how these effects might develop even in adulthood. Mark Wallace will investigate how changes in multisensory temporal abilities affect more complex behaviors, such as social cognition, by looking at children with and without ASD. Robert Jertberg will provide a glimpse into the way temporal dynamics can influence a multisensory illusion and how mismatched audiovisual stimuli can conversely alter perception of temporal relationships between stimuli. Erik van der Burg will discuss the way competition between stimuli can influence perception of temporal relationships, and the manner in which temporal recalibration can help the brain determine which sights and sounds to integrate when there are multiple viable alternatives. Together, these presentations will elucidate the complex reciprocal relationship between temporal and multisensory processing, the functions of features like temporal recalibration in facilitating integration of relevant multisensory stimuli, and what the differences in certain populations reveal about the development of these related features of perception.

Audiovisual Synchrony Perception in Adults with and without Autism

Weiland, Ricarda Florine[1], Polderman, Tinca JC[1], Smit, Dirk JA[2], Begeer, Sander[1], Van der Burg, Erik[3];
[1]Vrije Universiteit Amsterdam, [2]Amsterdam UMC, The Netherlands, [3]Universiteit van Amsterdam, The Netherlands

Integration of slightly asynchronous audiovisual information is aided by multiple mechanisms. Two examples of those mechanisms are a tolerance for asynchronies (so-called temporal binding window/ TBW), and the ability to quickly recalibrate to asynchronies (so-called rapid recalibration). Both mechanisms have previously been found to be altered in individuals with Autism Spectrum Disorder (ASD). Here, we investigated both processes in an adult sample (ASD: n=75, no ASD: n=85). In the experiment, participants indicated whether they perceived pairs of audiovisual stimuli with varying stimulus onset asynchronies as synchronous or not. Based on their synchrony distributions, the width of their TBW, and magnitude of the recalibration effect based on one, two, and three trials back were calculated. Contrary to previous research, we did not find group differences in either the width of the TBW, or the magnitude or duration of the rapid recalibration effect. To explain the lack of group differences, we explored age-related changes per group. While TBW did not change with age in the ASD group, in the non-ASD group both younger (ca. 19- 21 years) and older (ca. 42-50 years) participants showed larger TBWs. The rapid recalibration effect was relatively consistent in the ASD group, however, in the non-ASD group only younger (< ca. 38 years) participants showed a significant recalibration effect. Additionally, neither measure was correlated to self-reported autistic traits. While the age effects might explain part of the lack of group difference, other explanations include a change of ASD criteria in the last decade.

Multisensory temporal function in autism

Wallace, Mark T[1], Noel, Jean-Paul[2], Stevenson, Ryan Andrew[3], Woynaroski, Tiffany G[1];
[1]Vanderbilt University, Nashville, TN, USA, [2]New York University, New York, NY, USA, [3]Western University, London, Ontario, Canada

Alterations in sensory function are now recognized as a common feature of autism spectrum disorder (ASD). In addition to differences in unisensory function, there is increasingly evidence that these sensory alterations extend into the multisensory arena. The current work focuses on one aspect of these multisensory alterations in ASD, changes in multisensory temporal abilities. Specifically, we have found that many children with ASD tend to integrate or bind audiovisual stimuli over larger windows of time relative to typically developing children. Evidence will be presented detailing these changes, but perhaps more importantly, in showing how differences in multisensory temporal acuity relate to the core clinical symptoms that characterize ASD (i.e., deficits in social communication). Such work suggests that multisensory temporal function scaffolds certain aspects of higher-order cognitive abilities. In addition, evidence will be presented detailing the plasticity of multisensory temporal function in children with autism over multiple time scales. A better understanding of such plasticity could be of great value in the design of remediation approaches that target multisensory temporal function.

Temporal Dynamics of the McGurk Effect in Autism

Jertberg, Robert[1], Begeer, Sander[1], Geurts, Hilde[2], Chakrabarti, Bhismadev[3], Van der Burg, Erik[2];
[1]Vrije Universiteit Amsterdam, The Netherlands, [2]Universiteit van Amsterdam, The Netherlands, [3]Reading University; UK

Individuals with Autism Spectrum Disorder have been found to have impaired integration of multisensory stimuli, which translates to diminished susceptibility to multisensory illusions like the McGurk effect. Additionally, research has shown that autism is associated with diminished temporal acuity of the senses. However, the exact nature of the influence of temporal dynamics on multisensory integration in autism remains an understudied topic. For this reason, we created an online version of the classic McGurk effect, manipulated stimulus onset asynchrony between the phonemes and visemes, and asked autistic and neurotypical participants to respond both to what syllable they perceived and to whether or not the sight and sound were simultaneous. We then analyzed synchrony distributions and rates of the McGurk effect to evaluate the influence of temporal dynamics on multisensory integration in individuals with and without autism. Our findings resonated with previous research and elucidated the relationship between the impairment of temporal and multisensory processing in autism. Additionally, both groups showed dramatically impoverished temporal acuity with mismatched stimuli, such that when the phonemes and visemes were incongruent, they were much less likely to perceive them as synchronized, even when they were. This suggests a reciprocal relationship, wherein temporal dynamics influence the integration of sight and sound, and congruence (or incongruence) between them can conversely affect perception of temporal synchrony. These findings enrich both our understanding of the relationship between temporal processing deficits and multisensory impairments in autism and our understanding of the reciprocal nature of the relationship between these features in neurotypicals.

From Cacophony to Synchrony: Multisensory Integration and Recalibration with Competing Stimuli

Van der Burg, Erik[1], Jertberg, Robert[2], Kruijne, Wouter[3];
[1]Universiteit van Amsterdam, [2]Vrije Universiteit Amsterdam, [3]Rijksuniversiteit Groningen

It is known that the brain's temporal window for integration shifts when exposed to asynchronies (i.e., rapid recalibration), and that any stimuli that fall within this window can be integrated. However, paradigms typically use pairs of isolated audio-visual stimuli. This raises questions regarding external validity, as in natural scenes each sound has many possible visual counterparts. Here, we introduce a more naturalistic problem for the brain to solve, by introducing multiple visual stimuli competing to be related to one auditory source. Our results indicate that visual competition produces profound interference, both in integration of audio-visual pairs and in recalibration to their specific degree of asynchrony. We found a massive interference effect of visual competing stimuli: where participants would accurately recognize physical simultaneity 91% of the time without competition, they only did so 26% of the time with competition. This staggering illusion contradicts the notion that temporal synchrony alone is sufficient to produce integration. Additionally, we found that interference effect emerged both when participants were allowed to freely respond to whether either of two competing visual stimuli is synchronized with the auditory stimulus or were given a target, albeit slightly attenuated in the latter condition. This illustrates that integration and recalibration are both implicit phenomena, which can only be slightly modulated by attention. Critically, our results demonstrate the (cognitive) function of rapid recalibration: by biasing competition in accordance to previously experienced asynchronies, recalibration guides the interpretation of multiple visual candidate sources of auditory information.

Thursday Morning Symposium Talks

Thursday Symposium

10:15am - 11:15am

Room Lago

Advances in Neural Modelling of Multisensory Integration

Shaikh, Danish

Multisensory integration (MSI) has been studied extensively for the past several decades for various combinations of sensory modalities. These studies have generated extensive evidence that the combination of information from multiple senses allows for lower response times, reduced uncertainty, leading to improved detection, discrimination, and recognition and the formation of unified and robust percepts. The neuroscience and computational modelling community has contributed immensely to the meteoric rise in research in MSI, as evident by the fact that almost half of the publications in MSI in the last decade have come from the neurosciences. The success of Bayesian approaches in modelling MSI at a higher level has dominated modelling work, but there are still many open questions regarding the neural mechanisms and circuits underlying MSI. Advances in machine learning, neural networks and AI have opened new and exciting avenues in modelling MSI at the mechanistic level. This symposium aims to bring together researchers working on neural models of MSI via mathematical/computational/machine learning/connectionist/AI approaches. The goal of this symposium is to highlight single-neuron and/or network models of neural mechanisms underlying multisensory binding, cue combination, multisensory effects and developmental MSI as well as the role of neural plasticity, learning and memory models.

Drift-diffusion models of tactile reaction times with looming auditory stimuli

Sancristobal, Belen[1], Ferri, Francesca[2], Perrucci, Mauro Gianni[3], Romani, Gian Luca[3], Northoff, Georg[4], Longtin, Andre[5];
[1]Universitat Pompeu Fabra Barcelona, [2]University of Ottawa Institute of Mental Health Research, [3]Institute of Advanced Biomedical Technologies, Gabriele D'Annunzio University, [4]Royal Ottawa Mental Health Centre, [5]University of Ottawa

We have analyzed the reaction time (RT) responses of humans during looming (increasing acoustic intensity) and flat (constant acoustic intensity) sounds. Participants were blindfolded and asked to respond as fast as possible to a tactile target, when present, by pressing a button and trying to ignore the auditory stimulus (multisensory condition). The tactile stimulus was delivered at varying temporal delays from the onset of the auditory stimulus (Ferri, F. et al. Neuroimage 2015). We have used two models of evidence accumulation to find the best fit to the reaction time distributions. Namely, we have used two versions of the random walk with drift that consider a different number of parameters. The former assumes three parameters (the drift, the boundary for decision and the time non-related to the decision process, or non-decision time) and leads to the shifted Wald distribution (Anders, R. et al. APS, 2016). The latter, the so-called drift diffusion model (DDM), considers two more parameters representing the variance of the non-decision time and the drift (Ratcliff, R. and Vand Dongen, H.P.A. PNAS, 2011). Moreover, we use the electroencephalogram (EEG) of the same participants recorded during passive listening of the same sounds and in the absence of motor response (unisensory condition) to predict the RTs. We have found that the DDM of Ratcliff accurately reproduces our data and we show which parameters better correlate with the neuronal activity. The findings show that the main parameter that is varying with the looming stimulus is the non-decision time.

Multi-sensory integration in the mouse cortical connectome using a network diffusion model

Shadi, Kamal, Dyer, Eva, Dovrolis, Constantine;
Georgia Institute of Technology

Having a structural network representation of connectivity in the brain is instrumental in analyzing communication dynamics and information processing in the brain. In this work, we make steps towards understanding multi-sensory information flow and integration using a network diffusion approach. In particular, we model the flow of evoked activity, initiated by stimuli at primary sensory regions, using the Asynchronous Linear Threshold (ALT) diffusion model. The ALT model captures how evoked activity that originates at a given region of the cortex “ripples through” other brain regions (referred to as an activation cascade). By comparing the model results to functional datasets based on Voltage Sensitive Dye (VSD) imaging, we find that in most cases the ALT model predicts the temporal ordering of an activation cascade correctly. Our results on the Mouse Connectivity Atlas from the Allen Institute for Brain Science show that a small number of brain regions are involved in many primary sensory streams – the claustrum and the parietal temporal cortex being at the top of the list. This suggests that the cortex relies on an hourglass architecture to first integrate and compress multi-sensory information from multiple sensory regions, before utilizing that lower-dimensionality representation in higher-level association regions and more complex cognitive tasks.

Efficient coding as the provenance of matched and opposite neuronal feature preferences for multisensory and multi-modal inputs

Li, Zhaoping;
Max Planck Institute of Biological Cybernetics

When inputs from different sources are correlated, coding them efficiently requires new representations (also called bases) in which the signals are decorrelated. For two sources, this implies two bases involving the respective weighted sum and difference of the inputs. Efficient coding explains many neural receptive field properties in early vision. For example, in stereo coding, some V1 neurons prefer the sum of inputs from the two eyes and other V1 neurons prefer the difference of these inputs. Input correlation also appears deeper in the brain when multisensory inputs or different unisensory cues converge. For example, medial superior temporal (MST) cortical neurons sense heading direction of self-motion based on optic flow and vestibular inputs; middle temporal (MT) cortical neurons sense depth from binocular disparity and motion parallax. Analogous to stereo, efficient coding predicts that the preferred features (heading direction or depth) from different sources should be matched in some neurons and opposite in others, as indeed is found in MST and MT. Efficient coding thus accounts for the existence of opposite neurons, which appear useless for cue integration, and instead convey information missed by the matched neurons when input sources are only partially redundant. It predicts how the exact forms (i.e., relative weighting of the sources) of, and neural sensitivities to, individual bases, manifested by the matched and opposite neurons, should adapt to the statistical properties of the inputs (e.g., the correlation between the sources and signal to noise ratios).

Learning priors: modelling developmental multisensory cue combination

Shaikh, Danish;
University of Southern Denmark

Multimodal sensory cue combination is a fundamental process in the brain by which stimulus cues from different sensory modalities are combined to form a coherent and unified representation of observed events in the world. Psychophysical evidence for multimodal cue combination is accounted for by Bayesian models at the single neuron as well as population level that apply a weighted sum to multimodal cues. Cues are weighted by their corresponding reliabilities that are derived from their corresponding likelihood functions (having multivariate Gaussian or Poisson distributions) which represent neuronal responses. This ensures that the combination result is biased towards the more reliable cue. The underlying assumption that all Bayesian approaches share is that the synaptic weights that are meant to represent cue reliabilities are fixed because the corresponding likelihood functions are known and fixed. However, neurophysiological evidence from recording of multisensory neuron responses suggests that the synaptic weights increase or decrease with relative cue reliability (Morgan et al. 2008; Fetsch et al., 2012). I present a Hebbian-like, temporal correlation learning-based, adaptive neural circuit for multimodal sensory cue combination that learns to adapt its modality-specific synaptic weights according to the modality-specific reliabilities of the sensory cues. The circuit is based solely on temporal correlations between spatial information extracted from spatially congruent events in the participating sensory modalities. The circuit is therefore able to extract and encode information about sensory cue reliability on a moment-by-moment basis in response to dynamic changes in noisy sensory stimuli without requiring any prior statistical information about the stimuli.

Thursday Morning Symposium Talks

Thursday Symposium

11:30am - 1:00pm

Room Danube

Deafness and blindness as insights into cognition

Cardin, Velia

The remarkable capacity of the brain for functional and structural reorganisation is known as neural plasticity. Human congenital deafness and blindness result in anatomical and functional changes that affect sensory and cognitive processing, providing unique insights into our understanding of crossmodal plasticity and the brain. The vast majority of the research on crossmodal plasticity focuses on the sensory consequences of these models, with much less focus on the unique information that they provide for our understanding of cognitive processes in the brain. Studying cognitive processes in congenitally deaf and blind individuals unravels the impact that sensory developmental experience has on the organisation of cognitive networks in the brain, and how these processes are differentially affected by nature and nurture. This symposium brings together world leaders in the study of deafness and blindness at all stages of their careers to discuss the mechanisms that result in activity in the same cortical region supporting different perceptual and cognitive experiences in deaf, blind, hearing and sighted individuals. This multidisciplinary group of speakers will discuss psychophysical, neuroimaging and electrophysiological studies revealing the functional and anatomical reorganisation caused by deafness and blindness, and their consequences on cognitive processes such as working memory, attention, language, numerical, spatial and social cognition. They will also discuss whether sensory cortices acquire prominent roles in cognitive processing after sensory deprivation, and how this relates to current theories of crossmodal plasticity. In summary, this symposium will show that models of sensory absence provide not only an opportunity to learn about crossmodal plasticity but also about the capabilities of the brain.

Multisensory processing of prosodic information in cochlear implanted deaf patients.

Barone, Pascal[1], Lasfargue, Anne[2], Deguine, Olivier[2], Marx, Mathieu[2];
[1]Université Toulouse, France., [2]Hopital Purpan, Toulouse, France.

The cochlear implant (CI) allows profoundly postlingual deaf patients to recover speech intelligibility through long-term adaptive processes to build coherent percepts from the coarse information delivered by the implant. The recovery relies on a progressive visuo-auditory synergy and a capacity of the CI patients to fuse visual and auditory speech information. But verbal communication is also intrinsically characterized by prosody which communicates intent, emotion, speech segmentation. Prosody is also fundamentally a multisensory process in which visual facial cues are associated with auditory prosodic cues within a sentence. As linguistic prosody is poorly encoded by a CI processor, we explored how adult CI patients process MS prosodic information when they have to discriminate a question from a statement. While CI patients are not better performers than hearing controls in the visual discrimination of prosodic cues, they present a higher multisensory gain in bimodal conditions, reflecting a high proficiency to fuse MS linguistic prosodic information. This benefice which is nearly absent in NHS, relies in CIP on a specific oculomotor strategy during face exploration. The supra-normal skills of CI patients in processing MS speech information (Rouger et al PNAS 2007) can be extended to paralinguistic information while it remains in the normal range for low-level information processing. It corresponds to an adaptive strategy restricted to cognitive speech-related processing and relies on the functional adaptation of the brain network involved in speech and multisensory integration (Strelnikov et al Hear. Res. 2015).

How technology, life experiences and mental imagination shapes brain specialization and can be used for visual and auditory impairments

Amedi, Amir;
Baruch Ivcher Institute For Brain, Mind & Technology, Interdisciplinary Center Herzliya – IDC & Baruch Ivcher School of Psychology IDC, Israel.

This talk will discuss principles driving specializations in the human brain and their dependence on specific experiences during development (i.e. critical/sensitive periods) versus learning in the adult brain. Specifically, I will focus on studying Nature vs. Nurture factors in shaping up category selectivity in the human brain (ERC project BrainVisionRehab). A key part of the project involves the use of Visual-to-Auditory Sensory-Substitution-Devices (SSD). In the second part of the talk I will cover a speech-to-touch sensory substitution approach which improves performance of hearing impaired in noisy environments. I will discuss the Technology, Behavior and Neural Correlates of this novel SSD. I will also discuss initial results from our new ERC ExperieSense project which focuses on studying Nature vs. Nurture factors in shaping topographical maps in the brain. Our work strongly encourages a paradigm shift in the conceptualization of the brain by suggesting that visual experience during critical periods is not necessary to develop anatomically consistent specializations in higher-order 'visual' or 'auditory' regions. This also has implications for rehabilitation by suggesting that multisensory rather than unisensory training might be more effective.

What early auditory deprivation tells us about multisensory recognition of person identity in the human brain

Benetti, Stefania[1], Rabini, Giuseppe[1], Novello, Lisa[1], VanAckeren, Markus[1], Maffei, Chiara[2], Rezk, Mohamed[3], Zonca, Joshua[4], Rossion, Bruno[3], Pavani, Francesco[5], Jovicich, Jorge[1], Collignon, Olivier[3];
[1]University of Trento, Italy., [2]Massachusetts General Hospital, Charlestown, USA., [3]University of Louvain, Belgium, [4]Istituto Italiano di Tecnologia, Genova, Italy., [5]Centre de Recherche en Neuroscience de Lyon, France

In humans, one essential element of identity recognition is the integration of identity information across different modalities. In this talk, I will present our work on cross-modal plasticity within the face-voice processing systems of early profound deaf individuals and discuss the implications on the understanding of how cross-modal identity recognition is implemented in the human brain. In deaf individuals, the right 'deafened' temporal voice-selective area (TVA) functionally reorganises to process face stimuli and is capable of face identity discrimination within a time-window comparable with the one observed in the ipsilateral visual face-selective area (FFA). Selectivity to face identity in the reorganised TVA is most likely driven by feed-forward information from early visual regions rather than supra-modal associative regions. Finally, the study of anatomical connectivity suggests that heteromodal connections between visual and auditory regions provide a scaffolding for the subsequent developmental refinement of sensory integration during person recognition. These findings support the hypothesis that identity recognition does not necessarily engage supramodal feedback from associative regions but can result from the direct, early sharing of information between auditory voice and visual face regions (Von Kriegstain, 2005). Through pressure to integrate face and voice information for individual recognition, phylogenetic and ontogenetic experience may generate privileged links between the two systems, due to shared functional goals. Such links may be nested in the right hemisphere early during human brain development and be particularly susceptible to functional reorganization after sensory deprivation.

Data-driven classification of spectral profiles reveals brain region-specific plasticity

Rimmele, Johanna M.[1,2], Lubinus, Christina[1], Orpella, Joan[3], Keitel, Anne[4], Gudi-Mindermann, Helene[5], Engel, Andreas K.[2], Röder, Brigitte[5];
[1]Max-Planck-Institute for Empirical Aesthetics, Frankfurt aM., Germany; [2]University Medical Center Hamburg-Eppendorf, Germany, [3]Department of Psychology, New York University, USA, [4]University of Dundee, Scotland, UK, [5]University of Hamburg, Germany,

Brain rhythms are characteristic for anatomical areas and presumably involved in perceptual and cognitive processes. Whether visual deprivation related neuroplasticity involves altered spectral properties and which brain areas are particularly affected, is unknown. In a novel analysis approach, magnetoencephalography resting-state data of congenitally blind and sighted individuals were analyzed across cortex and a broad range of frequencies using clustering and classifier procedures. Remarkably, spectral profiles in auditory and right frontal areas showed increased neuronal power in higher frequency bands in the blind compared to the sighted, possibly reflecting acceleration of regionally prevalent brain rhythms due to increased temporal processing capabilities. Altered spectral profiles in visual areas, suggest changes in the visual inhibitory-excitatory circuits. Crucially, altered spectral profiles correlated with microstructural white matter properties in an extended posterior and bilateral cluster. We provide evidence for selectively altered spectral profiles due to visual deprivation-related plasticity, partly correlating with structural connectivity changes.

How visual is the number sense? Insights from blindness.

Crollen, Virginie;
Institute of Psychology (IPSY) and Institute of Neuroscience (IoNS), Université Catholique de Louvain, Belgium

Numbers play an important role in our daily lives, they are used in a variety of contexts (e.g., to use mobile phones, cook, deal with money, tell time, etc.) and are most of the time accessed and processed through the visual modality. This supremacy of vision in accessing numerical information has led some researchers to assume that number was a fundamental visual attribute principally processed through the neural recycling of some visuo-spatial brain areas. If this assumption is true, then the lack of early visual experience should impede the development of good numerical abilities. In this talk, I will review recent behavioural and imaging data examining numerical cognition in congenitally blind individuals. I will show that the lack of visual experience does not prevent the development of good numerical abilities, but nevertheless shapes some qualitative properties of the number representation. Within this context, the study of visually deprived individuals represents a unique opportunity to test the intrinsic relation between numerical cognition and vision and also provides important insights into the role played by visual experience in shaping the neural foundations of arithmetic reasoning.

Crossmodal plasticity and executive functions in deaf individuals

Cardin, Velia[1], Vinogradova, Valeria[1,2], Woll, Bencie[1], Eimer, Martin[3], Manini, Barbara[1];
[1]UCL, London, UK., [2]University of East Anglia, London, UK, [3]Birkbeck, University of London, UK.

When a sound is made in the environment, neurons fire in the auditory cortex of the brain, giving us the subjective experience of hearing. In congenitally deaf people, following a process known as crossmodal plasticity, this hearing machinery, rather than being redundant, is known to be used for sensory and cognitive processing in the visual and somatosensory modality. This talk will discuss how cognitive processing is reorganised in the brain as a consequence of deafness and crossmodal plasticity, contributing to our understanding of cognition and the brain. Previous work showed that posterior regions of the superior temporal cortex (pSTC), typically a part of the auditory cortex in hearing individuals, are recruited for visual working memory in deaf individuals. This could indicate a role in cognitive processing such as control, attention or inhibition, all of which are important for working memory. To dissociate between these functions and understand the role of the deaf STC in cognition, deaf individuals were scanned while performing four different executive function tasks: working memory, inhibition, task-switching, and planning. Findings from this study show that early sensory deprivation results in different profiles of activations between the deaf and hearing individuals. Specifically, the absence of auditory stimulation during early development modulated the functional reorganisation of temporal and frontoparietal regions differentially for each cognitive task. These findings will be discussed in the context of current theories of crossmodal plasticity.

Thursday Morning Symposium Talks

Thursday Symposium

11:30am - 1:00pm

Room Lago

The non-veridical perception of touch: psychological and neural mechanisms and current theoretical approaches

Kilteni, Konstantina; **Heed, Tobias**

Touch is a critical sense across the entire spectrum of human life. Yet there is a plethora of experimental and neural evidence suggesting that we are prone to many kinds of non-veridical perceptions of touch: for example, we can misattribute touch to fake hands, we can localize touch to non-stimulated limbs and we can misperceive the intensity of our own touch. This symposium will present current experimental and theoretical approaches that attempt to understand the underlying psychological and neural processes, the relevance of seemingly erroneous perception in everyday life, and theoretical ideas that integrate across multiple phenomena. It is our aim to bridge between different experimental paradigms and to go beyond effects bound to specialized experimental paradigms to lay the ground for wider-reaching theoretical ideas. Each talk is concerned with non-veridical percepts of touch. The symposium gathers multiple methodological and experimental multisensory approaches. We bring together systematic biases of tactile localization in healthy humans (Tobias Heed, Jared Medina), tactile intensity (Konstantina Kilteni), tactile percepts in the absence of any physical stimulation (Giulia Poerio), and the projection of touch outside the body and onto tools (Jared Medina). These diverse approaches to understanding tactile perception are connected by several threads that we will particularly highlight throughout the different talks; for instance, the relevance of priors of body posture (Tobias Heed, Jared Medina), a defining role of motor processing and movement on tactile perception (Tobias Heed, Konstantina Kilteni), and cross-sensory influences that affect and prime perception (Jared Medina, Giulia Poerio). Beyond linking their presented work to these themes, all speakers will devote a part of their talk to their current ideas of aspects that can contribute to an overarching theory of how we perceive our tactile sensory input.

(Mis)perceiving tactile location: Touch is coded anatomically, not externally, for tactile-spatial forced-choice tasks

Heed, Tobias;
Paris Lodron University Salzburg, Austria

When participants are asked to identify the limb on which a touch occurred, they err systematically, often with high confidence, when their limbs are crossed. It was widely accepted that these kinds of errors stem from a conflict between anatomical and external spatial information about the touched limb. However, recent experiments have suggested that such tactile forced-choice decisions are coded based on features that reflect anatomical characteristics such as the body side and type (e.g., hand vs. foot) of the touched limb. In contrast, limb location appeared to be coded externally for the choice between the task-assigned response limbs. We scrutinized such potential coding differences of stimulated vs. responding limbs in forced-choice limb identification decisions. In each trial, participants received a tactile stimulus on one of the feet ("stimulus limb") and identified the touched limb with a hand response ("response limb"). When participants reported the external location (side of space) of the touch, performance was strongly impaired by stimulus limb crossing, but markedly less by response limb crossing. This effect was modulated in opposite direction when participants reported the anatomical touch location (body side). Furthermore, external-spatial stimulus-response compatibility improved performance under external, but not under anatomical instructions. Thus, we confirm that what may look like external effects for tactile coding in forced-choice limb assignment tasks actually reflects anatomically-based characteristics of the touch, mixed with externally-coded effects related to the response limbs required by the task and by top-down modulation induced by task instructions.

(Mis)perceiving tactile location using the mirror box illusion: Examining the relationship between perceived touch and embodiment

Medina, Jared;
University of Delaware, Delaware, USA

What are the constraints for our sense of embodiment? And how does embodiment relate to where we feel touch? We used the mirror box illusion to examine these questions. In our first series of experiments, we used mirrors to create the illusion of a "disconnected hand" with no forearm. To do this, we placed a small mirror in which only their hand reflection was visible with empty space where their forearm should be, with the participant's actual hidden hand located 15 cm behind the mirror. Bimanual synchronous finger-tapping in this condition created illusory embodiment of the mirror-reflected hand sans-forearm, and (at times) the sense that their forearm was in empty space. During this illusion, we then touched the hand or forearm behind the mirror and asked participants to localize the touch. When embodying the invisible forearm, participants often reported feeling touch in the empty "forearm" space, suggesting that constraints from the body schema can override visual information, leading to out-of-body touch. Furthermore, participants dissociated where they felt touch versus where they located their hand, often reporting "embodiment" of the mirror-reflected hand while simultaneously localizing the touch to the actual hand location. Similar results were also reported in a second series of experiments in which participants viewed a biomechanically impossible hand reflection in a mirror directly facing them. These results demonstrate that embodiment and referred tactile sensations are separable phenomenon and suggest that more evidence is necessary to create illusory touch versus body ownership.

(Mis)perceiving touch intensity: action prediction attenuates self-generated touches compared to externally generated ones

Kilteni, Konstantina;
Karolinska Institute, Sweden

Since the early 1970s, several behavioral studies have shown that self-generated touch feels less intense and less ticklish than the same touch applied externally. According to a prevalent computational theory of motor control, this attenuation occurs because the brain uses internal forward models to predict the somatosensory consequences of our movements using a copy of the motor command, i.e., the efference copy. These tactile predictions are then used to suppress the perceived intensity of the actual tactile feedback. Despite being highly influential, little is known about the computational principles and the neurophysiological basis of this phenomenon. I will show data indicating that this misperception of somatosensory intensity occurs only during voluntary (and not during passive) movements, it depends on action prediction and not sensory expectations, and it is represented in the degree of functional connectivity between the cerebellum and the primary and secondary somatosensory areas. These findings suggest that the efference copy is necessary for the somatosensory attenuation and speak against a generic multisensory predictive model, or a generalized non-predictive gating process. In contrast, they favor the theory that internal models (probably implemented in the cerebellum) attenuate the activity in the somatosensory areas (primary and secondary somatosensory cortex) leading to the (mis)perception of our touch intensity.

Perceiving touch without tactile stimulation: the curious case of the 'Autonomous Sensory Meridian Response'

Poerio, Giulia, Gillmeister, Helge;
University of Essex

In conditions like mirror-touch synaesthesia (MTS) tactile percepts arise even though the body surface is not physically stimulated. This talk will focus on a related experience that is enjoying increasing empirical interest: Autonomous Sensory Meridian Response (ASMR). ASMR is a pseudo-scientific term used to describe the perception of pleasant tactile sensations (i.e., tingling) on the scalp and neck, a sensation often triggered by audiovisual stimulation, which can elicit feelings of euphoria and deep relaxation in susceptible individuals. The characterisation of ASMR as an audiovisual phenomenon, however, overlooks how tactile experiences are not just perceptual concurrents of ASMR but also commonly strong ASMR inducers: many of the frequently reported audiovisual triggers directly show or strongly imply (interpersonal) touch. In this talk we will show new work on the physiological correlates of ASMR (e.g., theta desynchronisation) and their (dis)similarity to and interaction with veridical affective and non-affective somatosensation and MTS. These findings show that, similar to MTS, ASMR may be characterised as veridical tactile percepts that are brought about by heightened sensory sensitivity to (implied) touch. We suggest that a common underlying neurocognitive mechanism for both ASMR and MTS may be one in which altered functional connectivity reduces the capacity for inhibitory suppression of sensory (MTS) and sensory-affective (ASMR) experiences in susceptible individuals.

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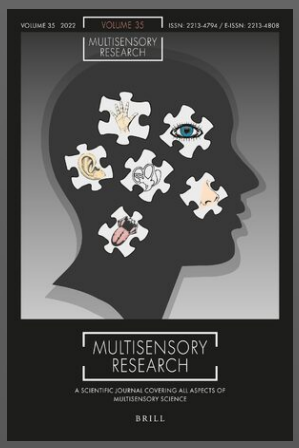

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Quantitative Methods for Visual Computing

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