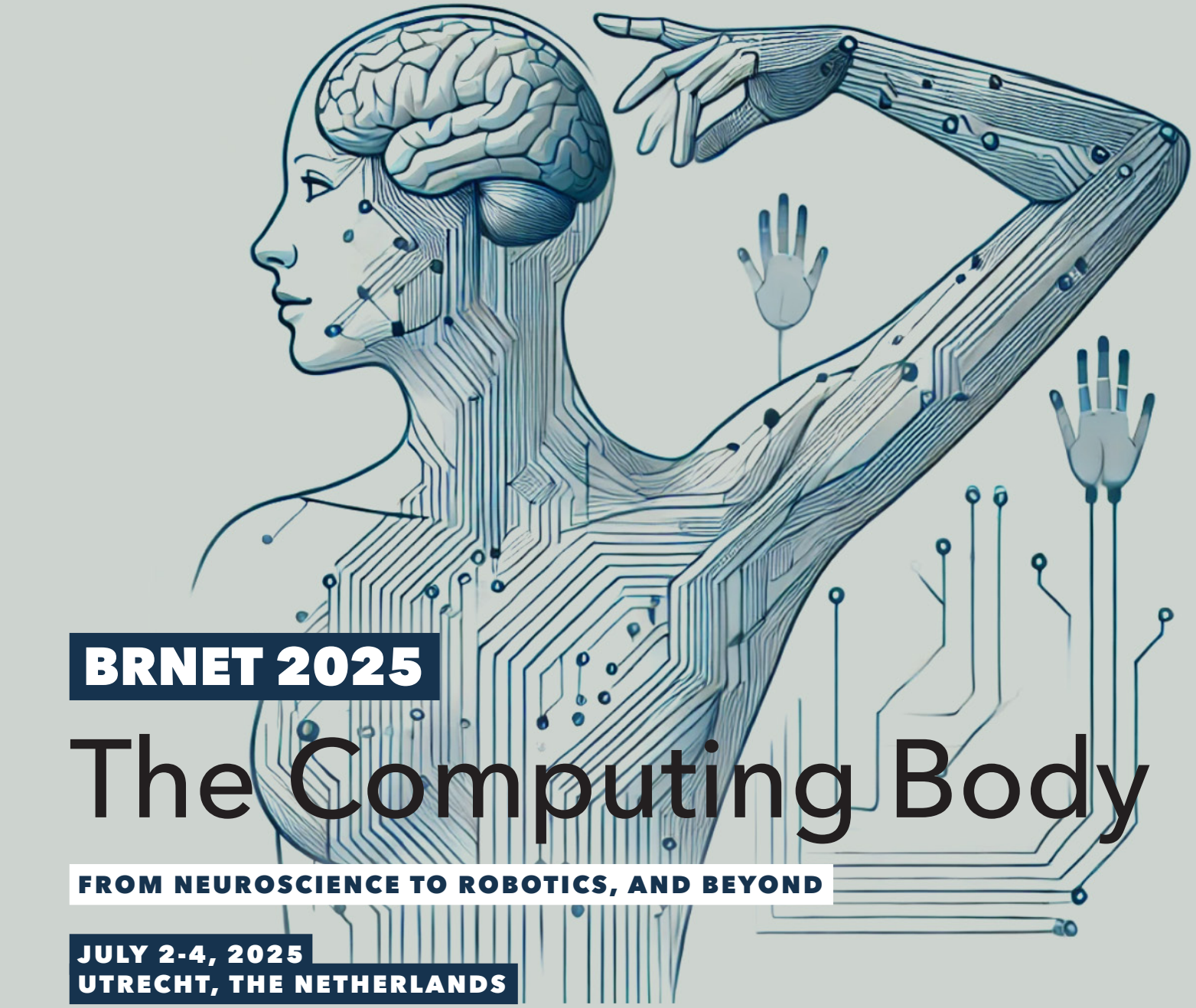

BRNET 2025

The Computing Body

FROM NEUROSCIENCE TO ROBOTICS, AND BEYOND

JULY 2-4, 2025
UTRECHT, THE NETHERLANDS

Universiteit Utrecht

DONDERS INSTITUTE

NWO

BRNET 2025

In order to sense and interact with the environment, an agent must continuously represent the state of the body, adapt to novel and unexpected environments, and accurately distinguish between self and other. The last several decades have seen an increasing number of influential conceptual models addressing these processes. For the 7th edition of BRNet, we will highlight computational approaches to understanding how the brain represents the body, focusing on the construction, maintenance, and flexibility of the body and the self. This “computational turn” is a relatively new approach in the field, with many open, unanswered, and unknown questions.

The program of the conference consists of a workshop on computational modelin, four keynote lectures (including the Early Career Researcher awardee) an ECR event and two sessions of short talks and posters.

Enjoy!

CONFERENCE ORGANIZERS

Utrecht University

Prof. Chris Dijkerman
c.dijkerman@uu.nl

Dr. Manja Engel
m.m.engel@uu.nl

Donders Institute for Brain, Cognition and Behavior, Radboud University

Dr. Luke Miller
luke.miller@donders.ru.nl

Dr. Konstantina Kilteni
konstantina.kilteni@donders.ru.nl

Dr. Valeria Peviani
valeria.peviani@donders.ru.nl

Dr. Dominika Radziun
dominika.radziun@donders.ru.nl

FUNDINGS

NWO-ENW Wetenschappelijke Bijeenkomsten en Ontmoetingen WBO 2024-1 (NWO Scientific Meeting and Consultation grant)

ERC Starting Grant 101076991 SOMATOGPS

VENUE

The conference will take place at the Utrecht University. Please note that we have two different locations for this conference. On Wednesday 2nd of July and Thursday 3rd from 14:00 we will be at the Drift. On Thursday the 3rd in the morning and Friday the 4th we will be at the University Hall. See the schedule for more info.

Drift 13 Drift 13, room 004 3512 BR Utrecht Public transport info	**University Hall** Domplein 29, Aula 3512 JE Utrecht Public transport info

Getting there
Traveling within the city is easiest with buses and trams. Traveling by bicycle is even easier for those who would like the full Dutch experience. Traveling by car is more difficult inside the city center. Utrecht also has a low emissions zone so not every car is allowed in the city center. For more information on how to travel in and to the city center please click here.

Drinks and food
Tea and coffee will be provided during the scheduled breaks.
Please note that, as this is a free conference, we kindly ask you to arrange and cover the costs of your own lunch and dinner. Luckily, the beautiful city of Utrecht is full of cafés, restaurants and food spots to explore – all within walking distance of the venue.

Points of interest
See our custom made google maps.

Wifi
To get online, text *Body2025* to +31 6 3525 0006 using your mobile phone. You will instantly receive your personal Eduroam username and password. Connect to the Eduroam network and log in with the details provided.

SCHEDULE

Day	Time	Venue	Event
Wed July 2nd	09:30-16:00	Drift	Registration
			Workshop: *Computational modeling for body representation*
	10:00-12:30		Part 1: distributions and generative models
	12:30-13:30		Lunch
	13:30-16:00		Part 2: model fitting
	16:30-17:30		Keynote: **W. Pieter Medendorp** (Donders Institute) *Steering your body around*
Thursday July 3rd	09:30-10:30	Uni Hall	Keynote: **Matej Hoffmann** (Czech University) *Understanding human body representations through humanoid robots*
	10:30-11:00		Break
	11:00-12:30		Poster session
	12:30-14:00		Lunch
	14:00-14:30	Drift	Short talks: **Alice Rossi Sebastiano** (University of Turin) *This is me: kinematic analysis of neonatal spontaneous movements reveals the propensity to explore the self-body*
	14:30-15:00		**Valeria C. Peviani** (Donders Institute) *A mirror symmetric spatial code maps touch on both hands in the human brain*
	15:00-15:30		**Dennis Larsson** (University of Sussex) *Temporal and spatial perception of heartbeat sensations in autistic adults*
	15:30-16:00		Break
	16:00-17:00		ECR award: **Jean-Paul Noel** (University of Minnesota) *New Models of Self-Location and Peri-Personal Space*
	17:00-18:30		Steering committee meeting
Friday July 4th	09:30-10:30	Uni Hall	Keynote: **Marie Chancel** (Aix-Marseille University) *Probably mine: an uncertainty-based causal inference framework for body ownership*
	10:30-11:00		Break
	11:00-11:30		Short talks: **Reinoud Kaldewaij** (Utrecht University) *TMS treatment for anorexia nervosa: effects on neural body image processing and clinical outcome measures*
	11:30-12:00		**Paula C. Salamone** (Linköping University) *Brain-spinal alterations of self-produced sensations in psychosis*
	12:00-12:30		**Micah Allen** (Aarhus University) *Computational Insights into Cardiac and Respiratory Interoception: Implications for Psychiatric and Somatic Disorders*
	12:30-14:00		Lunch
	14:00-15:30	Uni Hall	Poster session
	15:30-16:00		Break
	16:00-17:30		ECR event
	17:30-18:00		Poster prize and closure panel

KEYNOTES

Wednesday, July 2nd

W. Pieter Medendorp
Donders Institute for Brain, Behaviour and Cognition, Radboud University, Nijmegen, The Netherlands

Steering your body around

As embodied agents, humans make sense of the world through their physical presence and interactions. Many of our key behaviours—such as gesturing, walking, or driving a car—are inextricably linked to our embodiment in the real world. These behaviours are guided by a complex interplay of sensory signals, motor feedback, internal predictions, and cognitive processes. By leveraging normative frameworks—including systems identification, optimal control, and Bayesian inference— I will discuss some of the mechanisms that enable humans to adeptly steer their bodies and interact with the world around them.

Thursday, July 3rd

Matej Hoffmann
Czech Technical University in Prague, Czech Republic

Understanding human body representations through humanoid robots

The literature on body representations falls short of identifying mechanisms responsible for constructing, operating, and adapting “body models”. Coherent unified body representations are attractive but perhaps the mastery of our bodies should be best viewed as a “patchwork of skills”. In this talk, I will present a series of computational and embodied computational models on humanoid robots and discuss their potential to provide a mechanistic understanding of body representations and their development.

Friday, July 4th

Marie Chancel
Aix-Marseille University, Marseille, France

Probably mine: an uncertainty-based causal inference framework for body ownership

Body ownership, the perception that our limbs and body belong to us, emerges from the integration of multiple sensory signals. Despite extensive studies on visual, tactile, and proprioceptive contributions to this perception, the precise multisensory processes guiding subjective body ownership experience and their neural underpinnings continue to be an area of active investigation. A longstanding theoretical proposal suggests that Bayesian causal inference could account for how the brain decides whether a given sensory signal pertains to the self-body. However, direct empirical testing of this idea has been limited. In this talk, I will present a series of studies that use a novel psychophysical approach to the classic rubber hand illusion to formally examine the computational principles underlying body ownership. Specifically, we investigated how different forms of sensory uncertainty influence the emergence of body ownership, comparing Bayesian causal inference models with alternative, non-Bayesian accounts. We further used model-based fMRI to link behaviour to neural activity, revealing how trial-by-trial fluctuations in multisensory integration relate to the emergence of the illusion.
Together, these findings shed new light on the role of uncertainty in shaping bodily self-perception. They also suggest that the brain applies shared statistical principles to interpret both the self-body and the external world, offering a unifying perspective on perception and self-representation.

EARLY CAREER RESEARCHER EVENT

Organized by Lucy Stafford and Lara Coehlo (BRNet ECR reps)

Grants: Finding suitable funding opportunities, writing a compelling proposal, and understanding the application process.

Hear from a panel of grant experts on their experiences of finding, writing, and understanding the application process of grants. The panel will include post-doctoral researchers and tenured faculty. There will be a chance to ask live questions to panel members.

Please note this is an ECR only session.

EARLY CAREER AWARD 2025

The BRNet Early Career Award recognizes outstanding independent and original contributions to body representation research, highlighting individuals with the potential to become future leaders in the field. Eligible nominees must have obtained their PhD (or equivalent degree) within six years prior to the nomination deadline, with allowances for career breaks or part-time employment. Nominees can hold a permanent position, but for no more than two years. Nominations are judged on: i) the quality and originality of their research, and its significance to the field of body representation; ii) the research impact in and outside academia; iii) their leadership and independence; iv) mentorship to other researchers; v) their future potential and emerging influence in the field.

This year awardee is **Jean-Paul Noel,** *University of Minnesota, USA*

Title of the talk:
New Models of Self-Location and Peri-Personal Space

SHORT TALKS (July, 3rd)

1. Alice Rossi Sebastiano

Title: This is me: kinematic analysis of neonatal spontaneous movements reveals the propensity to explore the self-body

Full authors list: Rossi Sebastiano A., Italia B., Cagliero L., Frisenna E., Hoffmann M., Khoury J., Gama F., Borini G., Serra G., Peila C., Coscia A., Garbarini F.

First author affiliation: University of Turin

Keywords: newborns; kinematics; bodily self

Abstract: Early self-exploratory movements have been hypothesized to play a fundamental role in shaping a primitive bodily-self representation, as embodied sensorimotor experience may enable intermodal perception even in utero(1,2). Coherently with the involvement of self-exploration in this crucial developmental function, the observation of freely moving newborns suggests that, among spontaneous movements, self-directed ones (e.g., hand-to-face or hand-to-trunk contacts) are the most frequent. To provide quantitative evidence for this qualitative observation, the present study aims to systematically characterize the kinematic profile of spontaneous movements in newborns (N=40; 12-72 hours old) by combining video-recording in an ecological setting and automatic-tracking techniques using computer-vision algorithms. As a first step, a sub-sample of 13 newborns was manually scored by three independent experimenters, and hand movements were categorized into 4 trial types: 1) self-directed (toward the mouth, head, or trunk), 2) externally-directed (toward the environment), 3) body-time (duration of body contact), and 4) external-time (duration of stationary hand positioning in the environment). Preliminary analyses reveal significantly higher percentage of self-directed than externally-directed movements ($t=4.82$, $p=0.0004$), with no significant differences in mean trial duration. After establishing the correspondence with manual scoring and validation, we aim to test an automatic body pose estimation model in the whole dataset also extracting additional kinematic metrics(3). For instance, analysing the proportion of movement-time dedicated to deceleration could possibly show enhanced motor control when the movement target is the body itself. In conclusion, these findings provide preliminary quantitative evidence of the neonatal propensity to engage in self-directed movements, in line with qualitative observations(1). As a future step, automatic tracking will be implemented. In our view, by enabling the processing of large datasets acquired in highly ecological conditions (i.e., a simple video-recording), automatic tracking may represent an innovative tool that could help develop kinematic markers of typical development for early neurodevelopmental disorder prediction.

References: 1.Rochat P, Striano T. Perceived self in infancy. Infant Behav Dev 2001; 23: 513–530. https://doi.org/10.1016/S0163-6383(01)00055-8 2.Castiello U, Becchio C, Zoia S, et al. Wired to be social: The ontogeny of human interaction. PLoS One 2010; 5(10): e13199-13199. https://doi.org/10.1371/journal.pone.0013199. 3.Gama F, Misar M, Navara L, et al. Automatic infant 2D pose estimation from videos: comparing seven deep neural network methods. arXiv Preprint arXiv240617382 2024; 1–21.

2. Valeria C. Peviani

Title: A mirror symmetric spatial code maps touch on both hands in the human brain

Full authors list: Valeria C. Peviani, Hüseyin O. Elmas, W. Pieter Medendorp, Luke E. Miller

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: eeg; touch spatial coding; tactile remapping

Abstract: Extensive research showed that the somatosensory maps in the parietal lobe are organized somatotopically, representing the body surface in a structured manner. While such anatomical coding of touch is well understood, its functional coding is still rather unclear. Everyday actions, such as swatting a mosquito, require mapping the tactile input in skin-based coordinates onto a spatial reference frame that takes into account changes in body posture. Research so far has primarily compared neural responses to tactile stimuli in crossed vs. uncrossed arm positions, limiting insights into understanding which functional codes are used to represent the spatial location of touch. Here, we used EEG and high-density postural sampling to test whether tactile space is encoded in an absolute external coordinate system or a mirror-symmetric, joint-based coordinate system. We delivered electrocutanous stimuli to the hands in varying spatial positions. Using univariate and multivariate analyses we found evidence supporting a mirror-symmetric spatial code emerging at 150ms after stimulus onset. In the ERP analysis, this manifested as an amplitude gradient modulated by the spatial position of touch. The RSA further revealed a statistical relationship between the spatial distances among tactile stimuli and the associated neural activity patterns. These findings suggest that tactile localization relies on body-based representations rather than absolute spatial coordinates. These findings provide new insights into how the brain integrates somatosensory and proprioceptive information to guide action.

3. Dennis Larsson

Title: Temporal and spatial perception of heartbeat sensations in autistic adults

Full authors list: Larsson, D. E. O., Savage, H. S., Quadt, L., Mulcahy, J., Silva, M., Jones, A.-M., Strauss, C., Dienes, Z., Critchley, H. D., & Garfinkel, S. N.

First author affiliation: University of Sussex

Keywords: Interoception; Autism; Alexithymia

Abstract: Autistic individuals may differ in sensory processing with both hyper- and hyposensitivities documented in exteroceptive modalities. Additionally, divergent sensory processing of interoceptive (internal bodily) signals may commonly occur, but empirical research detailing interoceptive perception in autistic people is mixed. Using an interoceptive Method of Constant Stimuli task, we investigated heartbeat perception in autistic and comparison adult participants, both categorically and along a transdiagnostic spectrum of alexithymia. Results revealed significant group differences across subclinical measures of anxiety and alexithymia. However, no evidence for a group difference between autism and comparison group was found in terms of precision of heartbeat perception, heartbeat timing judgement, or perceived bodily location of heartbeat sensation. Our data suggest a possible floor effect in task performance, and lead us to question whether challenging psychophysics interoceptive tasks have the sensitivity to show nuanced group differences. Moreover, this sensory detection test is limited to the cardiac domain, and therefore may not capture broader interoceptive phenomenology in autism. Future research investigating interoception in the context of autism is needed, with accessible and ecological paradigms across different sensory axes.

SHORT TALKS (July 4th)

4. Reinoud Kaldewaij

Title: TMS treatment for aanorexia nervosa: effects on neural body image processing and clinical outcome measures

Full authors list: Reinoud Kaldewaij*, Rebecca Boehme*, Morgan Frost-Karlsson, Andrew Wold, Adam Enmalm, Magnus Thordstein, Per A Gustafsson, Håkan Olausson, Maria Zetterqvist

First author affiliation: Linköping University

Keywords: anorexia nervosa, TMS, extrastriate body area

Abstract: Anorexia nervosa is a severe and potentially lethal disorder characterized by self-starvation, weight loss, and distorted body image. Preoccupation with body shape is difficult to treat. It has been suggested that dysfunction of the extrastriate body area (EBA) plays a role in body-image distortion. In this project, we investigated the potential of transcranial magnetic theta burst stimulation (TMS) to the EBA. The protocol comprised four weeks of TMS combined with a specific body-image-perception training. Functional MRI was used pre- and post-treatment to asses neural activation patterns in response to body-related stimuli in the visual and tactile domain (self and social touch). We find improvements in our primary outcome measure, the body shape questionnaire, in the group receiving active TMS on the EBA (n=10) compared to sham (n=10) and compared to treatment as usual (n=20). Specifically, the active TMS group showed a longer-lasting decrease in BSQ scores than the sham-group at 6 months follow-up. This was accompanied by specific changes of the neural EBA response to self and social touch. These results contribute to our understanding of the pathophysiological mechanisms underlying body-image distortion in anorexia and identify a novel therapeutic target for neuromodulatory therapy.

5. Paula C. Salamone

Title: Brain-spinal alterations of self-produced sensations in psychosis

Full authors list: Paula C. Salamone*, Adam Enmalm*, Reinoud Kaldewaij, Marie Åman, Charlotte Medley, Michal Pietrzak, Håkan Olausson, Andrea Johansson Capusan, Rebecca Boehme

First author affiliation: Linköping University

Keywords: schizophrenia, interoception, self-other-distinction

Abstract: Psychosis is often characterized by disturbances in the sense of self, with patients frequently misattributing self-produced sensations to external sources. While somatic hallucinations and misperceptions are common, the underlying disruptions in basic bodily self-processing remain unclear.
We aimed to investigate alterations in bodily self-processing, including touch and interoception, in psychosis using a multimodal, multi-method approach. This case-control-study included a total of 70 participants (35 patients diagnosed with psychotic disorders, 35 age- and sex-matched controls). Participants performed self-/other-touch-tasks and interoceptive assessments during functional MRI, evoked potentials measurements, and/or behavioural and psychophysical tests. Primary outcomes included neural and behavioural responses to self- and externally-generated sensations (touch and heartbeat). Brain activation, spinal evoked responses, heartbeat perception and processing (evoked responses), and behavioural measures were analysed, with preregistered hypotheses.
Patients demonstrated heightened neural activity during touch tasks, including increased right superior temporal gyrus activation during self-touch and heightened activity in a right temporoparietal cluster during social touch. Tactile self-other distinction impairments were evident at the spinal cord level. Behaviourally, patients showed reduced differentiation in tactile thresholds for self- vs. other-touch. Interoceptive impairments included diminished cortical responses to heartbeat signals, lower interoceptive accuracy (heartbeat detection), and reduced self-reported interoceptive sensitivity.
These findings reveal pervasive sensory and self-related disturbances in psychotic disorders. Impairments in differentiating self- and externally-evoked responses, detectable as early as the spinal cord level, may contribute to higher-order symptoms of psychosis.

6. Micah Allen

Title: Computational Insights into Cardiac and Respiratory Interoception: Implications for Psychiatric and Somatic Disorders

Full authors list: Micah Allen

First author affiliation: Aarhus University

Keywords: interoception, computational psychiatry, psychopharmacology

Abstract: Interoception, the perception of internal bodily states, shapes how agents represent themselves and adapt to a changing environment, supporting both self-awareness and the distinction between self and other. Traditional measures often focus narrowly on cardiac signals, neglecting other organ systems. Here, we introduce novel Bayesian psychophysics and hierarchical modeling approaches for quantifying interoceptive sensitivity, precision, and metacognition across cardiac and respiratory axes. Applying these computational frameworks, we demonstrate distinct interoceptive profiles in psychiatric and somatic disorders: patients with psychosis exhibit diminished sensitivity, while individuals with functional neurological disorders show increased precision. These findings point to disruptions in embodied self-awareness and highlight how computationally derived measures can reveal nuanced mechanistic deficits.

Building on these insights, we investigate whether noradrenergic beta-blockade can remediate or modulate interoceptive dysfunction. In a placebo-controlled, within-subject study (N=52), bisoprolol and propranolol both enhanced cardiac perceptual sensitivity, with only bisoprolol selectively boosting metacognition. Both drugs increased respiratory perceptual precision, suggesting a pivotal role of peripheral noradrenaline in orchestrating interoceptive processes across organ systems.

Taken together, these studies illustrate how computational modeling can bridge the gap between basic physiological metrics and therapeutic applications, shedding new light on the neural and physiological underpinnings of embodied self-representation and pointing toward potential interventions for disorders characterized by altered interoception.

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Nikolova, N., Harrison, O., Toohey, S., Brændholt, M., Legrand, N., Correa, C., ... & Allen, M. (2022). The respiratory resistance sensitivity task: An automated method for quantifying respiratory interoception and metacognition. Biological Psychology, 170, 108325.

Allen, M. (2020). Unravelling the neurobiology of interoceptive inference. Trends in Cognitive Sciences, 24(4), 265-266.

POSTER LIST

No	Presenter	Title
Thursday, July 3rd		
1	Ilkay Ari	Causing a robot to display happy but not sad facial expression leads to sensory attenuation: evidence from EEG
2	Celia Blaise	Where do we draw the line between our physical bodies and the external world? A psychophysical analysis
3	Federico Brusa	Mental motor chronometry tasks for hands, feet, and the whole body: data from anorexia nervosa and bulimia nervosa
4	Diego Candia-Rivera	Brain connectivity and cardiac activity covary with motor imagery learning
5	Giulia Cera	Body uneasiness in bulimia and anorexia nervosa: exploring the role of eating symptoms
6	Ishan-Singh Chauhan	Peripersonal Space-Time: temporal sensitivity of space dependent visuo-tactile integration
7	Thomas Chazelle	A Bayesian approach to interpersonal influence on body size perception: A proof of concept
8	Noa Cemeljic	Sensorimotor predictions dynamically modulate somatosensory perception during movements to self-touch
9	Lara Coelho	Mismatched Maps: Distorted Structural and Functional Body Representations in Childhood
10	Francesco Crottini	Modulating the metric body representation through thermosensory stimulation: a preliminary study
11	Anna Crossland	Experiencing internal bodily signals during pregnancy: A scale development study
12	Mariano D'Angelo	Parietal alpha frequency shapes own-body perception by modulating the temporal integration of bodily signals
13	Habibe Sena Dündar	Body Dysmorphia Tendency and Face Pareidolia Processing
14	Huseyin Orkun Elmas	Bayesian modeling reveals distinct priors for tactile and proprioceptive localization
15	Fotini Eracleous	Refining the Tactile Imagery Ability Assessment Tool (TIAAT): Toward a Comprehensive, Multidimensional Measure of Tactile-Specific Imagery
16	Jacopo Elettari	Thermal embodiment: exploring the rubber hand illusion with visuo-thermal feedback
17	Celia Foster	Constructing a multisensory body representation of an additional robotic body part
18	Francesca Frisco	Holding a tool updates Body Schema without active movements
19	Xaver Fuchs	Rabbit on a stick—Spatiotemporal integration on hand-held tools
20	Filipe Gama	The role of self-touch in body schema development
21	Ayla Gay	Bias in Hand Perception: A Systematic Review
22	Siebe Geurts	Proprioceptive adaptation to finger-extending exoskeletons
23	Matteo Girondini	Influence of Virtual-Reality-Based Body Hemispatial Illusion During Visuomotor Interaction on Peripheral Physiological Activity
24	Sofia Gentili	Computational Approach to body ownership in Anorexia Nervosa
25	Louisa Gwynne	Pain alters corticospinal excitability whilst leaving sensorimotor interactions intact
26	Marta Guarischi	Feeling the body: hand representation in early and late blind adults

27	Qiu Han	Visual memory biases for body postures are explained by Bayesian integration of body-related priors
28	Anne Hoffmann	Linking tickle-perception to causal inference of self-generated touch
29	Kiki Houwers	Body Image in Non-binary and Genderqueer Adults – a Comparative Case Study
30	Paul Jenkinson	Risk, reward, and body representation: A computational perspective on decision-making in body-related behaviours
31	Ema Jugovic	A markerless 3D motion capture pipeline for human upper-body tracking during motor augmentation using an additional robotic thumb
32	April Karlinsky	The Emergence of Contrast Effects when Rating Body Types of Individuals who are Presented with Peers of Different Body Types
33	Jason Khoury	Tactile Localization Methods: A Review
34	Anouk Keizer	Social touch in patients with a personality disorder
35	Konstantina Kilteni	Why gargalesis, or simple tickle, still puzzles modern neuroscience
36	Ruth Knight	Hearing everybody: using coproduction in body image research
37	Arina Schippers	Embodying exoskeletal fingers changes their perceived weight
38	Sofia Tagini	Affective Touch in Anorexia Nervosa: The Importance of Who is Touching You and the Role of Attachment Dimensions
Friday, July 4th		
1	Jason Khoury	The Role of Early Self-Touch in the Emergence of Goal-Directed Self-Reaching
2	Carmen Lenatti	Body structural representations of the glabrous and hairy skin surface
3	Annika Lutz	Cardio-visual integration of body images: An investigation of visual and heartbeat evoked potentials
4	Renee Lustenhouwer	Combing the power of imagination with a loving hand: is tactile imagery more pleasant when it is affective?
5	Marika Mariano	Me in Action: using VR to explore the interaction between sense of agency and ownership
6	Isabella Martinelli	From youth to ageing: changes in hand ownership are driven by proprioceptive precision
7	Jamie Moffatt	Embodiment and adaptation to an extendable arm in children and adults
8	Hamide Beyza Muhtaroğlu	Recall of Information Learned Through Visual and Tactile Interaction: A Comparison of Virtual Reality and the Real World
9	Wendy Plétu	The psychophysiology of human tickle sensations
10	Dominika Radziun	Neurophysiological effects of training with a finger-extending exoskeleton: An EEG study
11	Wiktoria Rabińska	Developing a Virtual Reality Simulation – How Design Choices Shape Virtual Embodiment, Immersion, and Presence?
12	Gaia Risso	The impact of attentional focus on body perception of patients with functional motor disorders
13	Julien Russ	Does EMG afford superior control of an extra robotic body part?
14	Linda Sangalli	Where is my hand? The interaction between verbal manipulation and visual information in shaping one's perceived body location
15	Gerardo Salvato	The contribution of cutaneous thermal signals to bodily self-awareness
16	Juliane Schubert	Towards a representational body space based on active somatosensing
17	Manuela Sellitto	Focusing attention on bodily signals could reduce impulsive food choices
18	Oscar Sill	Structural Body Representation Accuracy Develops Throughout Life

19	Maura Simioni	Body Ownership alterations induced by Intracerebral Electrical Stimulations in the left insula and right frontal operculum: a case report
20	Maggie Szymanska	Expecting Pain: How Individuals with Phantom Limb Pain Integrate Sensory Evidence
21	Lucy Stafford	Restrictive disordered eating is related to reduced updating of prospective beliefs about sensitivity to satiation
22	Giulia Stanco	How acting using a tool shapes the implicit sense of agency in the near and far space
23	Tilman Stephani	Determinants of tickle: stimulus characteristics and neural correlates
24	Karunya Srinivasan	Body illusions changing assessment of affordances, body perception, and motor behaviour
25	Chatrin Suksasilp	Interoceptive training reduces anxiety and increases Bayesian precision weighting of cardiac signals
26	Sofia Tagini	Affective touch in obesity: who touches you does it matter?
27	Giorgia Tosi	The rubber hand illusion questionnaire: An exploratory graph analysis of ownership, referral of touch, and control statements
28	Arianna Vecchio	I feel fat: Altered spatial estimates of abdominal limits in adolescents with Restrictive Eating Disorder
29	Julian van Grondel	Interoception in somatic symptom disorder
30	Floris van Wettum	Optimal integration of a novel sound-to-space mapping into sensorimotor control loops
31	Peter Paul van de Wetering	Exploring the Neural Bases and Mechanisms of Induced Out of Body Experiences: A Literary Review
32	Shasha Wei	Altered vibrotactile signal combination in patients with chronic hand pain
33	Olga Wódecka	The Effect of Finger Size Distortions on Tactile Temporal-Order Judgments
34	Ziliang Xiong	Characterization of human tickling behavior and associated bodily maps of ticklishness
35	Fiammetta Zanetti	Implementation of a cardio-visual full-body illusion in Virtual Reality to enhance embodiment and address body image distortion

POSTER ABSTRACTS (July, 3rd)

1. Ilkay Ari

Title: Causing a robot to display happy but not sad facial expression leads to sensory attenuation: evidence from EEG

Full authors list: Ilkay Ari, Mateusz Wozniak, Davide De Tommaso, Agnieszka Wykowska

First author affiliation: Italian Institute of Technology

Keywords: sense of agency, human-robot interaction, emotional expressions

Abstract: Sensory attenuation (SA) refers to a reduced neural response to self-generated stimuli, compared to externally caused stimuli. This presumably reflects a diminished salience of expected outcomes. It is considered a neural signature of action-effect integration and has been linked to sense of agency, the subjective experience of having caused an outcome. However, whether SA applies to complex, socially relevant outcomes, such as emotional reactions, remains unclear. In this EEG study, we examined whether SA is modulated when emotional facial expressions become action-outcomes. In our task, in each trial participants selected which of two objects should be shown to a humanoid robot, iCub. In response, iCub displayed either a happy or sad facial expression. We also included a passive condition, where objects were selected by computer and not by participant. Results revealed significant P1 suppression for self-generated happy expression, whereas self-generated sad expression and passive conditions showed no attenuation. Our findings indicate that self-generated negative expressions might be processed as less expected, leading to increased sensory gain. This could reflect a self-serving bias, where individuals tend to attribute positive outcomes more strongly to themselves. Overall, results suggest that processing of socially relevant outcomes of our actions can shape early perceptual processing.

References: Gentsch, A., Weiss, C., Spengler, S., Synofzik, M., & Schütz-Bosbach, S. (2015). Doing good or bad: How interactions between action and emotion expectations shape the sense of agency. Social neuroscience, 10(4), 418-430.

Lombardi, M., Roselli, C., Kompatsiari, K., Rospo, F., Natale, L., & Wykowska, A. (2023). The impact of facial expression and communicative gaze of a humanoid robot on individual Sense of Agency. Scientific Reports, 13(1), 10113.

Osumi, T., Tsuji, K., Shibata, M., & Umeda, S. (2019). Machiavellianism and early neural responses to others' facial expressions caused by one's own decisions. Psychiatry research, 271, 669-677.

2. Celia Blaise

Title: Where do we draw the line between our physical bodies and the external world? A psychophysical analysis

Full authors list: Celia R Blaise, Holly C Clark, Hannes P Saal

First author affiliation: University of Sheffield

Keywords: body representation, body boundary, psychophysics

Abstract: The ability to distinguish between our body and the external world is crucial for our sense of self, environmental interaction, and sensory processing. In this study, we developed a psychophysical protocol to directly assess how accurately individuals perceive their body boundaries. Participants were asked to determine whether the midpoint between two tactile stimuli applied on the skin was inside or outside their perceived body boundary. 3D scans of the tested regions were used to determine objective anatomical boundaries, allowing psychometric functions to be fitted. Participants showed millimeter-level precision in body boundary localization across diverse body regions, including the palm and the ankle. However, accuracy varied depending on the body region. While palm boundaries were judged almost perfectly, wrist boundaries were frequently misjudged, even when the midpoint was located considerably outside the physical body. Perceptual judgements adapted to changes in posture, but did not simply reflect proprioceptive input: eliminating local three-dimensional structure considerably impaired localization accuracy. These findings suggest that body representations accurately reflect local body geometry with high fidelity.

3. Federico Brusa

Title: Mental motor chronometry tasks for hands, feet, and the whole body: data from anorexia nervosa and bulimia nervosa

Full authors list: Federico Brusa, Myrto Efstathiou, Anna Sedda, Giulia Cera, Margherita Boltri, Valentina Villa, Enrica Ventura, Emanuela Apicella, Gianluca Castelnuovo, Leonardo Mendolicchio, Federica Scarpina

First author affiliation: IRCCS Istituto Auxologico Italiano

Keywords: motor imagery, anorexia nervosa, bulimia nervosa

Abstract: Motor imagery (MI) refers to the mental recall of a movement without physical execution and is used to explore mental representations of the body. Individuals with eating disorders such as anorexia nervosa (AN) and bulimia nervosa (BN) experience body image distortions and show impairments in MI tasks. These impairments suggest altered MI processes in AN and BN [1,2]. This study aimed to explore explicit MI processes in individuals with different types of AN (restrictive vs. binge-purging) and BN by comparing their performance with that of healthy controls (HCs). To achieve this, we assessed participants using the mental motor chronometry (MMC) task in its classic version, which focuses on hand movements, as well as two alternative versions that focus on foot movements (alternative control single-limb stimulus) and whole-body movements [3].
Individuals with restrictive AN, binge-purge AN, and BN experience body misperception, overestimating their body size (i.e., perceiving their body as larger than it actually is). As a result, compared to HCs, these individuals were expected to take longer to imagine movements than to execute them, especially for whole-body movements. Contrary to our hypothesis, we did not observe any group differences (i.e., similar performance between HCs and individuals with eating disorders). However, within the sample of individuals with restrictive AN and BN, we identified a specific pattern: imagining hand and foot movements took longer than imagining whole-body movements. Despite perceiving their body as larger than it is, the increased imagery time was observed specifically for individual body parts. On one hand, this finding suggests that results from individual body parts cannot be generalized to the whole body when assessing MI processes. On the other hand, it offers a new perspective on MI processes in individuals with eating disorders (i.e. compulsive self-monitoring).

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4. Diego Candia-Rivera

Title: Brain connectivity and cardiac activity covary with motor imagery learning

Full authors list: Diego Candia-Rivera, Mario Chavez, Fabrizio de Vico Fallani, Marie-Constance Corsi

First author affiliation: Sorbonne Université

Keywords: Brain-heart interaction, Motor imagery, Brain-computer interfaces

Abstract: Motor imagery is the mental simulation of movement without physical execution, which is widely used in brain-computer interfaces (BCIs) and neurorehabilitation. Performing motor imagery effectively and assessing its performance remain challenging. While most efforts to improve BCIs have focused on advancing computational methods for decoding physiological signals, a fundamental question on which are the physiological mechanisms persist. Recent research highlights the active role of interoceptive inputs in bodily self-awareness, influencing aspects such as body ownership and self-other distinction. However, the role of brain-heart interactions in motor imagery remains largely unexplored. We hypothesized that motor imagery significantly modulates brain-heart interactions and that these interactions can reliably track the BCI learning process over time.

In a cohort of 20 participants performing hand grasping motor imagery over four separate sessions, we recorded brain activity (MEG, EEG, MRI) and heart activity (ECG) to investigate these interactions. As participants acquired BCI skills, we observed two key behavioral and physiological changes: (1) reinforcement of motor-related brain activity, which translated into improvements in BCI accuracy on effectively performing the motor imagery task, and (2) a progressive functional disconnection between brain regions, accompanied by a reduction in heart activity, in both heart rate and rhythm. These patterns reflected increasing automaticity in BCI performance and showed potential for predicting future learning rates.

Overall, our findings provide new insights into large-scale neural network dynamics during BCI learning, with implications for enhancing this technology in real-world applications.

5. Giulia Cera

Title: Body uneasiness in bulimia and anorexia nervosa: exploring the role of eating symptoms

Full authors list: Giulia Cera, Federico Brusa, Carolina Gabutti, Margherita Boltri, Ilaria Bastoni, Valentina Villa, Enrica Ventura, Emanuela Apicella, Gianluca Castelnuovo, Leonardo Mendolicchio, Luigi De Gennaro, Serena Scarpelli, Federica Scarpina

First author affiliation: Istituto Auxologico Italiano & University of Rome - La Sapienza

Keywords: Body Uneasiness, Anorexia nervosa, Bulimia nervosa

Abstract: Introduction: This retrospective correlational study aimed to test whether eating symptoms may predict body uneasiness in two sample of women with a diagnosis of anorexia nervosa or of bulimia nervosa and compare this prediction among the two diagnoses. Body uneasiness was assessed with the Body Uneasiness Test (Cuzzolaro et al., 2006), while, the expression of eating symptoms was assessed with the Eating Disorders Inventory-3 (Garner, 2004). Method: 100 women with bulimia nervosa (mean age 28.4) and 70 with anorexia nervosa (mean age 24.5) completed the measures (Eating Disorders Inventory-3 and Body Uneasiness Test) at their admission to the hospital for their rehabilitation program, before any treatment. Results: In the sample of patients with anorexia nervosa, the Global Score from the Body Uneasiness Test was significantly predicted by the Drive for Thinness ($p < .01$), the Ineffectiveness ($p < .05$) and the Affective Problems Composite ($p < .01$) scores. Also, in the same sample, the Positive Symptom Total score was not predicted by any of the scores from the Eating Disorder Inventor-3, while the Positive Symptom Distress Index was significantly predicted by the Body Dissatisfaction and the Affective Problems Composite (both $p < .05$) scores. In the sample affected by bulimia nervosa, the Global Score from the Body Uneasiness Test was significantly predicted by the Drive for Thinness ($p < .01$) and the Ineffectiveness ($p < .05$) scores, while the Positive Symptom Total score was only significantly predicted by the Interpersonal Problems Composite score ($p < .05$). Finally, the Positive Symptom Distress Index was significantly predicted only by the Body Dissatisfaction ($p < .05$) score.
Conclusions: In both the samples, body uneasiness is predicted by 1) the patients' sense of being ineffectiveness, as well as by their feelings of emotional isolation and low self-esteem, and 2) by their strive to be thinner.

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6. Ishan-Singh Chauhan

Title: Peripersonal Space-Time: temporal sensitivity of space dependent visuo-tactile integration

Full authors list: Ishan-Singh Chauhan, Anna Custo, Tommaso Bertoni, Andrea Serino

First author affiliation: University of Lausanne

Keywords: peripersonal space - time – eeg

Abstract: PeriPersonal Space (PPS) refers to the representation of the space surrounding the body, allowing physical interactions between the individual and the environment. PPS has been often described as an enhanced integration of tactile information with exteroceptive information in a distance dependent-manner, allowing contact prediction. Knowledge on how temporal features of body and external stimuli determines this distance-dependent integration is lacking. In the present study, healthy participants underwent a classical PPS paradigm during which a tactile stimulus was delivered to the hand while visual stimuli were presented at various distances from the body. Crucially, various delays were applied between the tactile and visual stimuli, allowing to orthogonally manipulate contingencies between bodily and external stimuli both in time and space. For the different delay and distance combinations, PPS activation was measured through a validated EEG index based on spectral power desynchronization, capturing multisensory integration. We hypothesized that PPS activation should be modulated as a function of both spatial and temporal features of visuo-tactile stimulation, accordingly to natural spatiotemporal regularities. That is, the PPS index should be stronger when stimuli are close, or far, in both space and time. Such results could suggest that the concept of PPS should be reframed as PeriPersonal Space-Time (PPST), to account for both the spatial and the temporal dimensions.

7. Thomas Chazelle

Title: A Bayesian approach to interpersonal influence on body size perception: A proof of concept

Full authors list: Chazelle, T., Guerraz, M., & Palluel-Germain, R.

First author affiliation: University of Durham

Keywords: Body size perception, Multicue integration, Weight labels

Abstract: Body representation relies on the integration of different sources of information (i.e., cues). The way in which multiple sensory cues are combined has been described effectively by Bayesian models. Can this approach be extended to non-sensory cues, such as verbal information coming from other people? In a preregistered study, we investigated how weight labels (“thin”, “fat”) interact with visual information (pictures of a female body) in judgements of body size. In a two-alternative forced choice procedure, 10 participants judged the body size of targets described by either a weight label, a picture, or both types of cues providing conflicting information. We used the participants' responses in single-cue trials (verbal or visual cue) to predict the optimal behaviour in multi-cue trials (verbal and visual cues). We found that participants actually produced more error when both cues were available, contrary to the predictions of the optimal model. This proof-of-concept study highlights that, although we were able to use a computational approach similar to multisensory studies, verbal and social cues might follow different integration rules than sensory cues.

8. Noa Cemeljic

Title: Sensorimotor predictions dynamically modulate somatosensory perception during movements to self-touch

Full authors list: Noa Cemeljic, Xavier Job, Konstantina Kilteni

First author affiliation: Karolinska Institutet

Keywords: Sensorimotor predictions, self-touch attenuation, somatosensory perception

Abstract: Self-touch feels less intense than an identical external touch delivered by another person or a robot (1). This distinction arises because the brain can predict the somatosensory consequences of voluntary movements using a copy of the motor command before the self-touch is received (2). However, it remains unclear how these sensorimotor predictions impact somatosensory perception before or after self-touch occurs. We addressed this question in several behavioural experiments where participants performed reaching movements with their right hand to touch their left hand. We quantified the perceived intensity of tactile stimuli delivered to their left hand at different times relative to the time of contact between the hands. We hypothesized that sensorimotor predictions continuously attenuate somatosensory perception during the movement to self-touch, which will be reflected in a gradual decrease in the perceived intensity of tactile stimuli during the movement, followed by an increase after the movement ends. We further hypothesized that sensorimotor context and visual input play important roles in forming and updating the sensorimotor predictions during the movements to self-touch. In line with our hypothesis, we showed that tactile stimuli were gradually perceived weaker as the movement progressed and predictions about the self-touch timing became more precise. The lowest perceived intensity occurred when the hands made contact, while the stimuli were perceived stronger after the movement ended (3). We replicated these results in a new group of participants and further demonstrated that if the movements did not generate expectations of self-touch, no gradual attenuation of somatosensory perception was present (3), underscoring the importance of sensorimotor context in the predictive attenuation of somatosensory perception. Third, we illustrate that without visual input, somatosensory perception is uniformly, rather than gradually, attenuated throughout the movement. This finding indicates that vision increases the precision of sensorimotor predictions during the movements to self-touch.

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9. Lara Coelho

Title: Mismatched Maps: Distorted Structural and Functional Body Representations in Childhood

Full authors list: Lara Coelho, Lucilla Cardinali, Cristina Becchio, Monica Gori

First author affiliation: Italian Institute of Technology

Keywords: Structural body representation, functional body representation, development

Abstract: Hand representation has consistently been reported to be distorted in healthy human adult populations. This raises an interesting paradox on how accurate manual actions can be possible if they are based on a distorted hand representation? The present study addresses this question from a developmental perspective. We asked a large cohort (N=84) of typically developing children aged 6-10, to perform a structural and functional body representation task. In the structural task, children were asked to localize three landmarks (elbow, wrist, and tip of the middle finger) while blindfolded and after tactile stimulation to each of the three landmarks. The functional task required children to estimate if their fully outstretched arm would be long enough to touch an object that was placed in front of them at various distances. Children exhibited distortions in both tasks however in opposite directions. In the structural task, hand length was overestimated but forearm length was accurate. In the functional task, children overestimated arm length. Additionally, there was no relationship between estimates in the structural and functional tasks. We argue that these results support the existence of multiple, independent body representations across development.

10. Francesco Crottini

Title: Modulating the metric body representation through thermosensory stimulation: a preliminary study

Full authors list: Francesco Crottini, Ayla Gay, Jonatan Muheim, Solaiman Shokur, Gabriella Bottini, Andrea Serino, Gerardo Salvato*, Michela Bassolino*

First author affiliation: University School for Advanced Studies IUSS Pavia/ Hes-so Valais Wallis

Keywords: Thermosensory; Body Metrics; Body representation

Abstract: It is now increasingly recognized that the experimental and pathological alterations of body ownership are linked to changes in skin temperature. Also, the peripheral modulation of limb temperature can affect the malleability of body ownership. However, the available evidence exclusively concerns the link between cutaneous thermal signals and body ownership, leaving open the question of whether thermosensory signals also contribute to other body representation components. In this study, we aimed to investigate whether thermal modulation of the hand can induce changes in the ability to perceive the limb dimensions in the absence of vision (metric body representation). Specifically, we tested eight neurotypical participants, asking them to localize four markers positioned on their hidden left arm (index fingertip, knuckle, wrist, and elbow), giving verbal cues to the experimenter who moved a stick with a reference marker accordingly (Body landmarks localization task). Real and perceived positions were recorded and quantified through a motion capture system (VICON). Each participant performed the task during three thermal stimulations, applied to the palm of their hand with an innovative custom-made Peltier-like device: neutral (no stimulation), cooling (baseline -5°C) and heating (baseline +5°C) conditions, in randomized order. Preliminary results indicated that the hand cooling condition provoked a greater underestimation of the perceived finger length compared to other conditions. Although preliminary, this result suggested that cold, non-painful stimulation may alter the metric body representations, demonstrating that thermosensory signals' role is not restricted to the body ownership.

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11. Anna Crossland

Title: Experiencing internal bodily signals during pregnancy: A scale development study

Full authors list: Anna Crossland, Catherine Preston

First author affiliation: University of York

Keywords: Interoception, pregnancy, scale development

Abstract: During pregnancy women perceive, interpret and react to bodily signals like fatigue and hunger (interoception) differently to the general population due to vast psychological and physiological changes during this time. Our research suggests that a key current self-reported interoception scale (MAIA) may not be valid for pregnant populations due to this, therefore we aimed to develop a pregnancy specific interoception scale using a mixed methods approach. A series of stages of scale development were undertaken starting with gathering qualitative data from focus groups of pregnant women to understand their bodily experiences during pregnancy. This data was then analysed and, with consideration of interoceptive theory, an initial scale of 53 items to measure pregnancy specific interoception was developed. Interviews with pregnant women, post-natal women and midwives (N=14) provided qualitative feedback on the interpretability and relevance of each item of the scale, and then the scale was piloted with pregnant women and midwives (N=50), which led to the adjustment or removal of some items. Validation data on the final scale of 40 items was collected from a large sample (N~400 after exclusions) who completed the scale online, along with scales measuring constructs that have been found to relate to interoception in the general population, including mental health to test the construct validity of the scale. Explorative Factor Analysis (EFA) was conducted to reveal the latent factor structure, verified by Confirmatory Factor Analysis (CFA) on a different sample (N~300 after exclusions). It is important to understand how interoception is experienced during pregnancy because it is considered a transdiagnostic factor across various mental health conditions, for which pregnancy represents increased vulnerability. This newly developed scale attempts to effectively and accurately measure the interoceptive experience during pregnancy.

12. Mariano D'Angelo

Title: Parietal alpha frequency shapes own-body perception by modulating the temporal integration of bodily signals

Full authors list: Mariano D'Angelo; Renzo C. Lanfranco; Marie Chancel; H. Henrik Ehrsson

First author affiliation: Karolinska Institutet

Keywords: Body ownership

Abstract: An influential proposal in cognitive neuroscience suggests that alpha-frequency brain oscillations constrain the temporal sampling of external sensory signals, shaping the temporal binding window (TBW)—the interval during which sensory signals are integrated [1,2]. However, whether alpha frequency determines the temporal integration of self-related sensory signals to generate the perception of the body as one's own (body ownership) remains unknown. Here, we demonstrate that individual alpha frequency (IAF) in the parietal cortex predicts TBWs and perceptual sensitivities in body ownership and visuotactile simultaneity judgment tasks. Across three experiments, two robotic arms delivered taps to the participants' own hand and a rubber hand placed in front of them. Participants performed: Body ownership judgments—indicating whether they perceived the rubber hand as their own (i.e., the rubber hand illusion); and (ii) Simultaneity judgments—assessing the synchronicity of taps on the rubber hand and their own hands. Experiment 1 showed that TBW and sensitivity to visuotactile simultaneity correlated with TBW and sensitivity to body ownership. Experiment 2 revealed that IAF in the parietal cortex predicts participants' TBWs and sensitivity to both body ownership and visuotactile simultaneity. Experiment 3 used brain stimulation to modulate cortical alpha frequency, demonstrating predicted changes in TBW and sensitivity. Finally, we fitted behavioral data to a Bayesian causal inference model of body ownership [3] and found that IAF is linked to sensory uncertainty, which refers to the reliability of sensory information. This suggests that IAF influences perceptual inference by modulating the reliability of multisensory asynchrony information. Our psychophysical, EEG, brain stimulation, and computational modeling results provide evidence that IAF mediates the temporal integration of visuotactile signals, shaping the sense of body ownership. The causal inference modeling identifies a computational mechanism, revealing that IAF determines the reliability of visuotactile signals in the probabilistic multisensory perceptual inference underlying body ownership

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13. Habibe Sena Dündar

Title: Body Dysmorphia Tendency and Face Pareidolia Processing

Full authors list: Habibe Sena Dündar

First author affiliation: Abdullah Gül University

Keywords: Body dysmorphia tendency, face perception, face pareidolia perception

Abstract: Research on face perception suggests that we process faces differently from objects—more holistically, by integrating features and their relationships. However, some exceptions exist. Studies show that individuals with Body Dysmorphic Disorder (BDD) tend to focus more on individual facial features rather than seeing faces as a whole. BDD is a psychopathology where individuals shows overfocusing on their perceived flaws in their bodies and faces. While much research has explored the perceptual differences in BDD, the role of attention in face processing is less understood. This study investigates whether attention plays a role in how individuals with BDD tendencies process faces, objects, and face pareidolia (seeing faces in random objects and patterns).

Using the attentional blink paradigm, we examined how attention influences recognition of these stimuli. Since face pareidolia requires both face and object processing, it may offer insights into differences in perception among those with BDD tendencies.

A total of 157 students (Mage = 24.70) participated, categorized into high and low BDD tendency groups based on their scores on the Body Image Disturbance Questionnaire and the Satisfaction and Dissatisfaction with Body Part Scale. They completed 108 trials, where a second target (T2) appeared after a first (T1) at intervals of 100 ms, 200 ms, or 300 ms. The T2 stimulus was either a face, an object, or a pareidolia face.

Results from a Repeated Measures ANOVA showed no significant differences between the groups in recognizing faces, objects, or pareidolia faces. However, stimulus type and time intervals significantly influenced recognition.

Overall, individuals with and without BDD tendencies performed similarly in recognizing all three types of stimuli. The findings, along with potential explanations, limitations, and future research directions, are discussed within the broader context of face perception literature.

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14. Huseyin Orkun Elmas

Title: Bayesian modeling reveals distinct priors for tactile and proprioceptive localization

Full authors list: Huseyin O. Elmas, Luke E. Miller, Pieter Medendorp

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: Bayesian Modeling, Tactile Localization, Proprioceptive Localization

Abstract: When a mosquito lands on your finger, swatting it requires your brain to compute its location in external space—which changes with posture. Two competing hypotheses explain how the brain solves this challenge: the integration hypothesis, where tactile signals are transformed into spatial coordinates by integrating touch and posture information; And the cue hypothesis, where touch cues a location on the body whose position is specified via proprioception, and no integration takes place. It is still an open question which hypothesis best describes the process of localizing the mosquito on your finger. In the present study, we used Bayesian modelling to adjudicate between them. if touch merely triggers proprioceptive localization (cue hypothesis), both localizing touch and body parts in space should rely on identical prior expectations about spatial layout; if they involve some different computational processes (integration hypothesis), their priors might differ. Applying a Bayesian modeling approach to tactile and proprioceptive localization allowed us to quantify these underlying priors. Twenty-one participants localized their fingers via proprioception or touch on their fingers, by indicating the perceived locations on a screen while their target hand remained occluded under the screen, across nine arm positions. We developed Bayesian model variants representing different accounts about underlying priors in tactile and proprioceptive localization, from fully shared (identical prior and likelihoods for tasks, representing cue hypothesis), to independent (separate parameters for prior and likelihood, representing integration hypothesis). Results revealed that the independent variant provided the best explanation for the behavioral data. The divergence in priors suggests that these localization processes do not rely on identical computational mechanisms, refuting the cueing hypothesis where touch merely acts as a cue for proprioceptive localization. Our findings suggest that tactile localization involves different processes, such as transformation from somatotopic to skin-based coordinates, beyond those used for proprioceptive localization.

15. Fotini Eracleous

Title: Refining the Tactile Imagery Ability Assessment Tool (TIAAT): Toward a Comprehensive, Multidimensional Measure of Tactile-Specific Imagery

Full authors list: Fotini Eracleous, Christian Cano, Renee Lustenhouwer

First author affiliation: Utrecht University

Keywords: Tactile Imagery; Body Representation; Sensorimotor Processing

Abstract: Tactile imagery refers to the ability to mentally simulate touch in the absence of external stimuli, however, this area remains underexplored in body representation research. While mental imagery plays a crucial role in cognition and sensorimotor processing, no validated tools currently exist to measure tactile imagery abilities exclusively. This study aimed to develop and evaluate a novel Tactile Imagery Ability Assessment Tool (TIAAT), based on O'Dowd et al. (2022), while also identifying patterns in mental touch representations that could inspire applications in cognitive rehabilitation and patient care. Sixty-five participants completed the TIAAT questionnaire, rating the vividness, controllability, and maintenance of imagined touch across both active (haptic) and passive (somatosensory) modalities. Participants' difficulty in imagining tactile sensations without visual aid was correlated with their overall imagery scores using Kendall's Tau analysis. Two repeated measures ANOVAs examined (1) how object properties interact with active touch aspects (e.g., texture, temperature) and (2) how different body parts influence ratings of passive touch sensations (e.g., stroking, pain).

Preliminary findings suggest that participants who struggled with tactile imagery without visual support tended to have slightly lower overall imagery scores. Additionally, object properties and active touch aspects interacted significantly, indicating that how an object is mentally represented depends on the tactile aspect being imagined. For body parts and passive touch properties, no significant interaction was found, though certain body parts were consistently imagined better than others. By uncovering patterns in tactile imagery representation, this study enhances understanding of how mental touch is processed in the brain. Given findings that tactile imagery activates similar brain areas as real touch (Chivukula et al., 2021), this research highlights the potential for mental touch as a tool in rehabilitation and patient care, offering new approaches for treating chronic pain, stress, and body representation disorders.

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16. Jacopo Elettari

Title: Thermal embodiment: exploring the rubber hand illusion with visuo-thermal feedback

Full authors list: Jacopo Elettari, Jonathan Muheim, Aline Brunner, Vittorio Gallese, Silvestro Micera, Solaiman Shokur

First author affiliation: Università degli studi di Parma

Keywords: Embodiment, Temperature, Rubber Hand Illusion (RHI)

Abstract: Recently, prosthetic devices have demonstrated the ability to restore phantom thermal sensations in upper limb amputees (Muheim et al., 2024; Iberite et al., 2023). Despite its promising potential, the extent to which thermoception could contribute to the embodiment of an artificial limb remains unclear.
In this study, we investigated, using a modified version of the Rubber Hand Illusion (RHI), how thermo-visual feedback could trigger embodiment of a silicone hand. 31 healthy right-handed participants (25.5 ± 4.4 years, 14 females) observed a rubber hand subject to thermal interactions while congruent stimulations were applied to their left hand. To disentangle the tactile component of the interaction, a fixed copper sheet covered the point of contact on the rubber hand. The experiment consisted of 4 conditions (2 cold and 2 hot). During the cold ones the experimenter repeatedly applied a cold (reusable) ice cube on the rubber hand for 18 times per trial. Behind an occluding board, a thermal stimulator provided controlled -6 degrees changes to the dorsal hand (metacarpal of the thumb). In one condition the temperature change was synchronous with the contact of the object on the rubber hand, while in the other it was asynchronous. This procedure was carried out with hot stimulation too (the ice cube was replaced by handwarmer and temperature change was +6 °C). Trials order was randomized. Using a standardized RHI questionnaire, participants reported a stronger illusion when thermal stimulation was synchronized with tactile interactions on the rubber hand. However, no significant proprioceptive drift was observed. Furthermore, our findings suggest that gender and body mass index may influence the strength of the illusion, warranting further investigation. These insights highlight the potential benefits of incorporating thermal feedback into prostheses to enhance embodiment. Understanding how individual differences shape this process could lead to personalized stimulation strategies tailored to each user’s characteristics.

17. Celia Foster

Title: Constructing a multisensory body representation of an additional robotic body part

Full authors list: Celia Foster, Eva Chapman, Mario Kleiner, Andrew Dott, Lucy Dowdall, Dani Clode, Tamar Makin

First author affiliation: University of Cambridge

Keywords: touch, proprioception, robotics

Abstract: Having an extra body part could expand our movement abilities. However, it is unclear whether we can incorporate additional limbs into our brain's body representation. Multisensory integration of touch location with body posture is crucial for us to be able to make movements to touched locations on our own body, as we must combine touch location and limb posture to derive a spatial target. In this study, we explored whether participants can integrate touch location and body posture for an additional robotic thumb, The Third Thumb (Dani Clode Design). We developed a marker-based motion tracking setup to record participants' pointing movements to touch stimuli on the Third Thumb. In each trial, participants felt a touch stimulation from one of four vibration motors on the Third Thumb and used intrinsic touch information, i.e. the touch sensations arriving at the connection of the Third Thumb with the side of their hand, to make a pointing movement towards the location on the Third Thumb they judged as the touch stimulus origin. Participants' vision was occluded during each trial and auditory cues were masked using white noise. Six different Third Thumb postures were used across the session. Participants could distinguish between different touch locations along the Third Thumb, demonstrating successful use of intrinsic touch for localisation. This ability has been previously shown for handheld tools. We explored differences in pointing behavioural performance across different Third Thumb postures and touch locations. Pointing performance was worse for touch locations at the Third Thumb tip compared to other locations along the Third Thumb. Our results demonstrate that participants can distinguish touch locations on a robotic body part and combine this with its posture to program a movement to this spatial location. Our future research will explore whether this ability is strengthened following intensive Third Thumb motor training.

18. Francesca Frisco

Title: Holding a tool updates Body Schema without active movements

Full authors list: Francesca Frisco, Claudio Brozzoli, Salam Bahmad, Eric Koun, Alice C. Roy, Angelo Maravita, Alessandro Farnè

First author affiliation: University of Milano-Bicocca

Keywords: Body Schema; Tactile Localisation; Tool Embodiment

Abstract: Using a tool to interact with objects placed beyond one's reach extends the perceived length of the morphological arm representation (i.e., Body Schema; Cardinali et al., 2009). Tools are treated as a body part and incorporated into the body, modifying the Body Schema (Iriki et al., 1996). Recent works have suggested that the human nervous system employs tools as body sensory extension. When holding a tool, somatosensory processing mechanisms of the body are repurposed to perceive the tool (Miller et al., 2018). However, whether wielding the tool in hand without performing any movement leads to a concurrent modulation of the Body Schema remains to be determined. Here, we aimed to investigate the effect of online tool incorporation into the Body Schema. Specifically, we tested the hypothesis that Body Schema modulations already occur while merely holding the tool in hand, without active movements. To this purpose, we assessed the Body Schema using the tactile localisation task during which participants held either a short or a long tool. In this task, participants were asked to point to a touch screen to indicate the perceived location of a tactile stimulation on their forearm. Our findings revealed that simply holding a tool alters the body's morphological representation, resulting in an extension of the perceived length of the arm. Consequently, active movement with the tool may not be critical in tool embodiment. It is possible that holding a tool promptly adapts our action potentials in space. Thus, the sensory system and Body Schema would be updated to facilitate better control of potential tool-related movements and their sensory consequences.

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19. Xaver Fuchs

Title: Rabbit on a stick—Spatiotemporal integration on hand-held tools

Full authors list: Xaver Fuchs, Luke Miller, Tobias Heed

First author affiliation: Cognitive Psychology, Department of Psychology, University of Salzburg, Salzburg, Austria

Keywords: touch, body, tools

Abstract: Humans can localize stimuli on hand-held tools with remarkable accuracy due to the brain's ability to efficiently interpret vibratory patterns propagating along the tool[1]. Although all vibrations are sensed by the same tactile receptors of the hand, different stimulus locations on the tool activate distinct areas of the primary somatosensory cortex indicating that the brain processes the stimuli on the tool in a similar way like stimuli presented at different skin locations[2]. However, does this skin-tool resemblance also hold for more complex touch perception involving integration of multiple stimuli across time and space? To address this question, we used the well-known tactile cutaneous rabbit illusion paradigm and compared the illusion between the arm and a hand-held tool.

Twenty-four participants received tactile stimuli on the left forearm or on a hand-held wooden stick (within-subject design with blocks in counterbalanced order). There were two stimuli per trial in two locations that were presented either in quick succession ("rabbit" trials) or with a delay ("control" trials). In each trial, the participants indicated the perceived locations of both stimuli.

We observed the cutaneous rabbit illusion on both the arm and the tool, that is, participants reported tactile stimuli to be closer to each other than they really were when they had been presented in fast succession. The effect size was comparable between arm and tool.

Our results clearly demonstrate the cutaneous rabbit illusion on a hand-held tool. This has several implications. First, it challenges the long-standing assumption that the illusion arises from the brain integrating rapid stimuli across multiple skin locations[3]. Second, the skin-tool resemblance extends beyond single-stimulus localization. Thus, independent of the localization mechanism (skin vs. tool), the same principles of spatiotemporal integration and perceptual construction known from tactile research apply —and reproduce the same perceptual illusions.

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20. Filipe Gama

Title: The role of self-touch in body schema development

Full authors list: Filipe Gama*, Ziliang Xiong*, Jason A.M. Khoury, Juraj Marusic, Konstantina Kilteni*, Matej Hoffmann*

First author affiliation: Czech Technical University in Prague

Keywords: self-touch, body schema development, embodied computational models

Abstract: Self-touch behaviors begin in utero and continue after birth, occurring frequently—on average, 10 to 15 times per minute [1]. These self-touch events manifest only in specific body configurations, result in time-locked tactile sensations from two different body parts, and change in their spatial distribution across the body with age. At the neural level, Sakata et al. [2] identified neurons in the superior parietal cortex of rhesus monkeys—referred to as “body-matching neurons”—that specifically fired when the body assumed a self-contact-inducing posture and received corresponding tactile stimuli.

However, how self-touch behaviors evolve throughout development remains unknown: do we touch our body more or less frequently as we grow older? From a functional perspective, self-touch represents a rich cross-modal experience and thus, it might play a crucial role in learning one’s own body structure. Specifically, self-touch may drive the development of the body schema—one’s internal representation of the “body in space”—and may therefore be particularly critical and more frequent in early development.

To address this hypothesis, we will present empirical data (“self-touch maps”) comparing self-touch statistics in infancy and adulthood. Additionally, through embodied computational models of baby robots exploring their bodies [3], we will speculate on the potential role of self-touch in shaping the development of a body schema.

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21. Ayla Gay

Title: Bias in Hand Perception: A Systematic Review

Full authors list: Ayla Gay, Valeria Peviani, Luke Miller, Martin Sattelmayer, Michela Bassolino

First author affiliation: Institute of Health Sciences

Keywords: body representation, metric body representations, systematic review

Abstract: Research on hand perception has highlighted that distortions are so prevalent that authors have stated, that in this field, "biases are not exceptions but the rule" (Bassolino & Becchio, 2023). Many studies have focused on the metric perception of the hand, consistently showing a bias in which the hand is perceived as shorter and wider than its actual dimensions across various tasks and populations (Longo, 2022). However, studies in other fields have highlighted different types of errors in hand perception obtained through numerous different tasks (Dandu et al., 2020). The heterogeneity of approaches and objectives results in a lack of an overall perspective on bias in hand perception.

To address this gap, we are conducting a systematic review, gathering papers from three databases (Embase, PubMed, PsycInfo). A blind dual-reviewer screening identified studies on upper limb perception in healthy adults, using tasks where the arm/hand served as proprioceptive target, independently of the response modality. Studies relying on memory to recall target positions were excluded.

Besides the known distortions in perceived hand dimension, our findings highlight other biases common at group level indicating spatial drifts or idiosyncratic errors. To better understand which factors contribute to these variations, we extracted key study characteristics, such as response modality (e.g. motor, verbal, tool), tested landmarks (e.g., fingertip, wrist), and target hand position (e.g flat, rotated) as well as participant demographics (age, sex, handedness) and sample size. Meta-regressions will help identify which factors significantly influence the observed biases. By clarifying the impact of different methodological choices on observed perceptual errors, our study provides a comprehensive framework for advancing our understanding of body representation mechanisms.

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22. Siebe Geurts

Title: Proprioceptive adaptation to finger-extending exoskeletons

Full authors list: Siebe Geurts, Dominika Radziun, Valeria Peviani, Luke E. Miller

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: body augmentation, tool use, proprioceptive localization

Abstract: Humans are uniquely skilled at using tools, a proficiency that may stem from the ability to integrate tools into body representation. Beyond tools, body augmentation devices are becoming increasingly relevant with technological advancements. While tool use has been extensively studied, less is known about how body augmentation influences body representation and how the user perceives the device itself. Here, we used finger-extending exoskeletons—a device that lies between a tool and a body augmentation—as a way to investigate these two questions.

Twenty healthy participants performed a proprioceptive localization task, identifying points on both their index finger and the exoskeletal finger. The task was conducted before and after a 45-minute familiarization period, during which participants performed motor tasks designed to enhance coordination with the finger extensions. We also employed a within-subject control, where participants underwent familiarization with a non-extending exoskeleton on a separate day.

We found that humans rapidly adapt to finger-extending exoskeletons in terms of both motor coordination and perception. While using the exoskeleton, both the finger and the exoskeleton representations showed similar signs of perceptual stretching. That is, participants localized individual portions on their finger and exoskeleton as farther apart after using them. Furthermore, the variability of responses increased proportionally with this change, suggesting that the proprioceptive spaces were indeed stretched. Furthermore. participants were able to localize the finger extensions using proprioception nearly as accurately as their own biological fingers. Notably, no significant changes followed the use of the control fingers. These findings suggest that the finger and exoskeleton become representationally integrated, but only when the exoskeletons were used. These findings into body-tool integration have important implications for the development of assistive technologies and our understanding of how humans interact with augmentative devices.

23. Matteo Girondini

Title: Influence of Virtual-Reality-Based Body Hemispatial Illusion During Visuomotor Interaction on Peripheral Physiological Activity

Full authors list: Matteo Girondini, Valentina Saccone, Massimo Montanaro, Alberto Gallace

First author affiliation: University of Milano-Bicocca

Keywords: Body Representation, Body Reference Frame, Physiological Body State

Abstract: A coherent sense of body ownership relies on the integration of top-down and bottom-up sensory signals1. Disrupting the coherence of these signals through experimental manipulations (e.g., the rubber hand illusion or mirror box illusion) has been shown to affect body representation and peripheral physiological activity, such as body temperature 2,3. However, recent studies have debated these findings 4.To further investigate the relationship between coherent body representation and physiological state, we developed an innovative paradigm designed to alter body-centered representation during a visuomotor task in virtual reality. Participants (n = 22) engaged in a 15-minute visuomotor task in which they used their right hand to manipulate a virtual cube with a stick. In the congruent condition, the virtual hand matched the actual right hand. In the incongruent condition, the right hand was visually replaced with a virtual left hand, inducing a shift in the perceived body midline. We measured the temperature of the unused left hand before (baseline) and during the task. Additionally, in the middle of the task, we recorded skin conductance responses to supra-threshold electro-cutaneous stimulations. Results showed a significant baseline-corrected temperature difference between conditions, with lower temperatures in the incongruent condition and higher temperatures in the congruent condition. Furthermore, skin conductance responses were reduced after the incongruent condition compared to the congruent condition. Overall, our findings demonstrate that body illusions disrupting the coherent body reference frame can induce changes in the physiological state, strengthening the link between body representation and peripheral body signals1.

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24. Sofia Gentili

Title: Computational Approach to body ownership in Anorexia Nervosa

Full authors list: Gentili, S.*, Risso, G.*, Meregalli, V., Girondini, M., Akselrod, M., Favaro, A., Bassolino, M., Serino, A.* & Collantoni, E.*

First author affiliation: University of Padua

Keywords: Multisensory Integration; Body Ownership; Anorexia Nervosa

Abstract: The multisensory integration of signals from different senses is crucial to developing an unambiguous percept of the environment and our body [1]. Body perceptual disturbances are a key feature of Anorexia Nervosa (AN) and impaired multisensory signals inflow and integration are suggested as possible factors affecting body perception in this disorder [2].
To test this hypothesis, here we aimed to quantitatively measure alterations related to the experience of owning a body, i.e Body Ownership (BO) in AN by examining the processing of multisensory information and its integration. We applied the visuo-proprioceptive disparity task (VPD) [3], during which participants were asked to reach a visual target while seeing a virtual hand displaced with respect to the actual position of their real, not visible, hand. Participants had to reach the target with their real hand (i.e., following proprioceptive information). As a behavioral proxy of BO, we analyzed the reaching error, defined as the distance between the target position and the real hand position at the end of the reaching and the explicit feeling of ownership for the virtual hand collected on same trials on a Likert scale.
18 patients with AN and 18 age-matched healthy controls took part in the experiment. AN did not explicitly report significantly different ownership ratings than HC. Crucially, our results show lower reaching error for AN than HC, particularly for higher disparities, suggesting that in noisy situations AN can ignore visual information about the body more than HC.
According to the Bayesian causal inference (CI) framework, the final reached position corresponds to the relative weight given to visual or proprioceptive information and the probability computed by the brain that the virtual hand is one's own (prior). Further analyses to fit the VPD data according to the Bayesian CI model are ongoing to unravel the mechanisms behind the different behaviors observed.

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25. Louisa Gwynne

Title: Pain alters corticospinal excitability whilst leaving sensorimotor interactions intact

Full authors list: Louisa Gwynne & Luigi Tamè

First author affiliation: University of Kent

Keywords: Sensorimotor, Pain, Touch

Abstract: Tactile inputs can suppress motor output through afferent inhibition, typically assessed by examining the effects of afferent stimulation on transcranial magnetic stimulation (TMS) induced corticospinal excitability (CSE; Tokimura et al., 2000). Afferent inhibition provides a model for understanding how somatosensory inputs and states modulate motor and sensorimotor processes essential for adaptive responses. This insight has clinical relevance to the management and treatment of some pain states given that they are frequently associated with disrupted corticospinal motor networks and sensorimotor disturbances.

We conducted two experiments to examine the modulation of CSE and afferent inhibition by touch and pain. In Experiment 1 (N=20), a single electrocutaneous stimulus preceded a TMS pulse over the right first dorsal interosseous (FDI) hotspot in the primary motor cortex (M1) at different temporal delays (TDs; 15, 25, 35, 45, 60 or 160 ms). This revealed significant inhibition of CSE at 25, 35 and 160 ms TDs ($p < .001$) and facilitation at a 60 ms TD ($p < .05$). Moreover, these effects were unaffected by the duration of electrocutaneous stimulation (0.2 vs 0.4 ms; $p = .28$). In experiment 2 (N=20), we examined the effects of moderate tonic cutaneous heat pain on corticomotor and sensorimotor processes. Moderate heat pain was delivered to the left forearm during the same afferent inhibition paradigm as in Experiment 1. Heat pain significantly inhibited CSE compared to painless conditions ($p = .02$), while afferent inhibition remained unaffected ($p = .18$). Therefore, pain and touch selectively modulate corticomotor processes. Specifically, heat pain reduces CSE while tactile sensorimotor interactions remained unaltered. These results support the notion that heat pain directly affects the motor cortex and, in this context, such modulation is not mediated by touch.

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26. Marta Guarischi

Title: Feeling the body: hand representation in early and late blind adults

Full authors list: Marta Guarischi, Lara Coelho, Serena Basta, Claudia Gonzalez, Monica Gori

First author affiliation: Italian Institute of Technology

Keywords: body model, hand, blind

Abstract: The body model of the hand has repeatedly been found to be distorted in sighted populations. These distortions are characterized by an overestimation of hand width and an underestimation of finger length. Interestingly, several studies have documented that when sighted participants perform the body model task with no vision available (i.e., blindfolded) these distortions are somewhat attenuated. Therefore, it is possible that visual feedback is responsible for driving these distortions. If this is the case, one would expect that blind subjects would have a more accurate body model of the hand. However, there is contradictory evidence to support this hypothesis, as other research has shown that blind subjects struggle with proprioceptive tasks and have more unreliable body representations. To clarify this issue, a group of early and late blind participants and a sighted control group completed the body model task. In this task, the participants were asked to point to 10 different landmarks (the tips and metacarpophalangeal joints) on their unseen hand. Our findings revealed that while late blind and sighted participants exhibited the typical body model distortions, early blind participants instead underestimated hand width, while retaining the systematic underestimation of finger length. These results suggest that early onset blindness leads to the development of a fundamentally different body model, however one that is still distorted. Implications in terms of motor function and neuroplasticity are discussed. Future studies will explore the development of this representation in blind children.

27. Qiu Han

Title: Visual memory biases for body postures are explained by Bayesian integration of body-related priors

Full authors list: Qiu Han, Leni Wei, Luke Miller, Marco Gandolfo, Marius V. Peelen

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: Body posture, visual memory, prior

Abstract: Body postures convey crucial information for social behavior and thus receive prioritized visual processing. Despite the importance of accurately processing body postures, previous studies have shown that the visual memory of other people's body postures is systematically biased. We hypothesized that these biases reflect Bayesian integration of prior beliefs about body postures with incoming sensory information. Using a match-to-sample adjustment task, we tested participants' memory for briefly presented arm postures lifted at different angles. We modeled participants' responses in this task using a Bayesian model of visual posture memory. Modeling results showed that: 1) The visual memory for arm angles is influenced by orientation processing, showing strong repulsive biases at near-cardinal angles that can be explained by efficient coding at the encoding level; 2) Remembered postures are biased downward, reflecting the attraction to a gravity prior; and 3) An additional prior that constrains memory to the kinematically possible range of arm postures, consistent with knowledge of body biomechanics, further explained participants' responses. These results together demonstrate that humans employ body-related prior knowledge for recalling remembered postures of other people, and that this prior knowledge takes effect through Bayesian integration.

28. Anne Hoffmann

Title: Linking tickle-perception to causal inference of self-generated touch

Full authors list: Anne Hoffmann & Konstantina Kilteni

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: Self-tickle, sensorimotor predictions, Bayesian causal inference

Abstract: Predictive motor control theories posit that the brain uses a copy of the motor command (i.e., an efference copy) to predict and attenuate self-generated touch, thereby distinguishing it from external touch. Previous research has shown that self-generated touch is attenuated by the brain, leading to a reduced perceived intensity[1] and reduced somatosensory neural responses[2]. Interestingly, this predictive attenuation process has been proposed to explain why we cannot tickle ourselves[3]. However, the precise mechanisms by which the brain estimates the source of tactile sensations and determines whether to attenuate the incoming touch remain unknown.

In this study, we present a novel computational approach to investigating why we cannot tickle ourselves. We built a self-tickle setup in which participants apply strokes to their foot sole using a robotic device controlled via a digitizing tablet. Contrary to previous studies, our robotic stimulator precisely controls the position, velocity, and force of the stimulation. During the experiments, participants experience spatiotemporal perturbations to their self-produced strokes, thus introducing inconsistencies between their predicted touch, based on their movement, and the received stimulation. By implementing and testing a Bayesian Causal Inference model, this study aims to link the perceived causality between movement and touch with ticklishness, as assessed both subjectively and through physiological markers such as electrodermal activity and heart rate.

We hypothesize that ticklishness is maximally suppressed when spatiotemporal perturbations between movement and touch are minimal, thereby increasing the probability that movement and touch share a common cause (i.e., the self). Determining the computational mechanism underlying the attenuation of self-generated touch will advance our understanding of how sensorimotor prediction deficits, such as those reported in patients with schizophrenia or cerebellar ataxia, link to their perceptual and motor symptoms.

29. Kiki Houwers

Title: Body Image in Non-binary and Genderqueer Adults – a Comparative Case Study

Full authors list: K. Houwers, A. Keizer

First author affiliation: Utrecht University

Keywords: Non-binary, Body Image, Gender Dysphoria

Abstract: Background

Non-binary and genderqueer (NBGQ) individuals often encounter barriers to accessing gender-affirming treatments despite experiencing gender dysphoria (1). This exclusion may partly result from a limited understanding of potential body representation disturbances and their psychological effects in NBGQ individuals. It is therefore crucial to systematically investigate the full scope of body representation disturbances in this group. Some preliminary, qualitive, evidence indicates that binary transgender and NBGQ individuals may experience body dissatisfaction in different ways (2, 3). Here we assess, quantitatively, for the first time, body dissatisfaction and emotional distress in NBGQ individuals.

Methods and results
NBGQ individuals (N = 12) and a matched control sample (N = 12) completed the Body Attitude Test (BAT) and the Depression, Anxiety, and Stress Scale 21 (DASS-21). Results on the BAT showed that NBGQ individuals trended towards feeling less familiarity towards their body than controls. Moreover, NBGQ also experienced higher levels of emotional distress. In addition, in both groups strong positive correlations were observed between body dissatisfaction and emotional distress, specifically for stress and anxiety.

Conclusion
These findings suggest that NBGQ individuals experience greater emotional distress than cisgender individuals, and that this may be related to body dissatisfaction. We solely focused on self-reported body dissatisfaction here, not yet on the full scope of body representation disturbances. The current findings do offer potential for future work: e.g. NBGQ individuals trend towards feeling less familiar with their body, which provides an interesting starting point for future, experimental, studies on interoceptive abilities in NBGQ individuals.

30. Paul Jenkinson

Title: Risk, reward, and body representation: A computational perspective on decision-making in body-related behaviours

Full authors list: Paul Jenkinson

First author affiliation: The Cairnmillar Institute

Keywords: computational modelling; decision-making; risk-taking

Abstract: Decisions about the body — whether to undergo cosmetic procedures, restrict food intake, or engage in body modification — are shaped by a complex interplay of cognitive, affective, and social influences. Despite growing interest in body representation and decision-making, the computational mechanisms underlying these behaviours remain poorly understood. This talk explores recent findings that apply behavioural paradigms and computational modelling to examine how individuals weigh risk and reward in body-related decision-making. Using probabilistic tasks and advanced modelling approaches, we identify distinct patterns of risk-taking: individuals with greater acceptance of cosmetic surgery exhibit reduced sensitivity to potential losses, whereas those with restrictive eating tendencies show heightened risk aversion in specific contexts. By disentangling the contributions of risk and uncertainty, these models provide new insights into the cognitive biases shaping embodied choices. By integrating computational approaches with research on body representation, this work highlights how decision-making frameworks can refine our understanding of body-related behaviours. Implications for interventions and public health messaging will also be discussed.

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31. Ema Jugovic

Title: A markerless 3D motion capture pipeline for human upper-body tracking during motor augmentation using an additional robotic thumb

Full authors list: Ema Jugovic, Celia Foster, Julien Russ, Viktorija Pavalkyte, Hristo Dimitrov, Tamar Makin

First author affiliation: University of Cambridge

Keywords: kinematics, markerless, augmentation

Abstract: Body movement tracking is a valuable tool for studying motor learning in healthy populations and identifying atypical movement patterns in clinical groups. Advances in markerless tracking technologies, combining object-detection and deep convolutional neural networks, have improved body landmark (e.g., joint) detection. However, achieving accurate 3D motion tracking remains challenging due to the need for specialised, synchronised cameras and software for multi-camera video recording and 3D landmark generation. Moreover, markerless tracking can be unreliable in cases where body landmarks are hard to detect, such as in individuals with unconventional body types or motor abilities, including prosthetics and body augmentation users. Addressing these limitations is crucial for broadening the accessibility of these techniques. Here, we developed a pipeline for 3D motion tracking of the entire human upper body during motor task performance with an additional robotic thumb, the Third Thumb (Dani Clode Design). We outline key considerations for video recording, including camera type (machine vision vs. webcams), camera placement, field-of-view overlap, and synchronisation via Arduino, as well as approaches for 3D camera calibration. Our processing pipeline involves extracting 2D joint coordinates using Google MediaPipe and applying triangulation in Anipose for 3D reconstruction. Additionally, we detail adaptations for high-quality markerless tracking in the presence of sensors, electrodes, and other devices on the body. Finally, we present preliminary 3D motion tracking data from participants using the Third Thumb, capturing subtle upper limb kinematics changes as they acquire skill with the device. This pipeline enhances the reliability and accessibility of 3D motion tracking for diverse research applications.

32. April Karlinsky

Title: The Emergence of Contrast Effects when Rating Body Types of Individuals who are Presented with Peers of Different Body Types

Full authors list: April Karlinsky, Shi Lu Wang, Chris Pilieci, Madison F. Vani, Catherine M. Sabiston, Timothy N. Welsh

Presenting author affiliation: University of Toronto

Keywords: Body Image, Body Schema, Cheerleader Effect

Abstract: The "Cheerleader Effect" refers to the finding that faces of individuals are perceived as more attractive when the faces are presented in groups compared to when the faces are presented alone. The current study was designed to examine if a Cheerleader Effect emerges for perceptions of body size by determining if the perception of body size is influenced by: 1) whether the body is presented in a group or alone; and, 2) the relative sizes of the bodies presented in the group. Participants (n=51 women; Mage=22.5 years) rated the perceived body size of a centrally-presented model on a continuous scale from "very thin" to "very heavy". There were 15 images of "target" models (5 body sizes by 3 model identities). Target models were presented either on their own or in groups of three. When presented in groups, the two models on either side of the central target model could have a similar body size or a body size that was smaller or larger than the central target model. These differences could vary by a small, medium, or large amount. Analysis of the ratings did not reveal an overall Cheerleader Effect because there were no differences between the ratings for a central model when the model was presented alone or alongside groupmates of a similar body size. A contrast effect emerged, however, in which the central model was rated as thinner when presented alongside groupmates of a heavier body size ($p<.05$), and as heavier when presented alongside groupmates of a thinner body size ($p<.05$). These effects became larger as the difference in body size between the central model and the groupmates increased ($ps<.05$). These findings indicate that the representation and perceptions of body size are influenced by factors and the body size of the others in a group.

33. Jason Khoury

Title: Tactile Localization Methods: A Review

Full authors list: Jason Khoury*, Xaver Fuchs*, Sergiu Popescu, Tobias Heed#, Matej Hoffmann#

First author affiliation: Czech Technical University in Prague

Keywords: tactile Localization, reaching, body representation

Abstract:
The ability to localize tactile stimulations is crucial for monitoring our body and interacting with the world. However, studies suggest that when doing so, we are not always accurate or precise. Researchers use a large variety of methods to investigate this issue, with tasks ranging from pointing directly (Fuchs et al., 2020) at the stimulus to verbally indicating the area touched (Harrar et al., 2013), to name but a few examples.
We classified different tactile localization methods and investigated how their specificities affect the localization. We conducted a systematic review of 106 articles. We extracted certain attributes such as the body locations used, the characteristics of the localization tasks (e.g., type of task, reporting method, spatial stimulus-response relationship), and proposed a quantitative comparison of localization accuracy and precision for most common methods.
Our review revealed a marked preference for pressure and vibration stimuli and specific target areas, namely the forearm and hands. We classified tasks into decision-based or indication-based, and further discriminated studies by separating tasks where participants had to locate a stimulus relative to another location or not.
We identified five reporting methods: reaching/pointing, verbal responses, showing location on an image, button press, and moving the touched body part. We created sub-categories differentiating between the degree of spatial transformation required and the degree to which spatial or anatomical responses were fostered during the response. Finally, we found an effect on precision and accuracy of method type for tactile localization on the dorsal forearm and dorsal hand.
By categorizing these methods and discussing the theoretical assumptions underlying them, we highlight the key challenges and pitfalls in tactile localization research. Our findings aim to guide future experimental designs, and improve our understanding of how this seemingly simple action works.

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Harrar, V., Pritchett, L. M., & Harris, L. R. (2013). Segmented space: measuring tactile localisation in body coordinates. Multisens Res, 26, 3-18.

34. Anouk Keizer

Title: Social touch in patients with a personality disorder

Full authors list: Anouk Keizer, Birgit Hasenack, Barbara Montagne

First author affiliation: Utrecht University

Keywords: social touch, personality disorders, psychiatry

Abstract: The C-Tactile system refers to a network of sensory receptors in the skin that respond to gentle, slow touch, such as a caress. The C-Tactile system is crucial in social touch. It is specifically tuned to the pressure, speed and temperature that corresponds to gentle human touch on the skin. Healthy individuals often evaluate social touch as very pleasant, in addition social touch has been identified as a buffer against distress. Research investigating whether these findings also generalize to patients suffering from a psychiatric disorder is scarce. In a series of studies we therefore compared patients suffering from a personality disorder with healthy individuals on touch deprivation, their evaluation of touch, as well as the distress buffering effects of touch.

We assessed touch deprivation with a questionnaire and found that patients report a higher level of touch deprivation than healthy controls. Touch evaluation was assessed with a touch task in which participants were touched with a soft brush at a C-Tactile optimal and non-optimal speed. After each touch trial participants rated the pleasantness of the touch. Here we found that patients rated CT optimal touch as significantly less pleasant than healthy individuals. To assess the distress buffering effects of touch we experimentally induced feelings of social exclusion in participants and investigated how being touched with a soft brush at a C-Tactile optimal and non-optimal speed would impact feelings of social exclusion. Our results showed that in both groups, both types of touch resulted in reduced feelings of social exclusion.

Taken together, these studies show that there are differences in social touch experiences and evaluation between healthy participants and patients suffering from a personality disorder. Although more research is needed, we believe that at this point, clinical practice could benefit from e.g. including questions about touch experiences in the clinical intake.

35. Konstantina Kilteni

Title: Why gargalesis, or simple tickle, still puzzles modern neuroscience

Full authors list: Konstantina Kilteni

First author affiliation: Donders Center of Cognition, Karolinska Institute

Keywords: ticklishness; somatosensory processing; human neuroscience

Abstract: Gargalesis, or tickle, is one of the most trivial yet enigmatic human behaviours. We do not know how a touch becomes ticklish or why we respond to other people's tickles but not our own. No theory satisfactorily explains why touch on some body areas feels more ticklish than on others, or why some people are highly sensitive while others remain unresponsive. Gargalesis is likely the earliest trigger for laughter in life, but it is unclear whether we laugh because we enjoy it. Socrates, Aristotle, Bacon, Galileo, Descartes, and Darwin theorized about tickling, but after two millennia of intense philosophical interest, experimentation remains scarce. In this poster, I reflect on the challenges in defining and eliciting ticklish sensations in the lab and unravelling their neural mechanism, discuss five classic yet unanswered questions about tickle, and suggest directions for future research. I argue that gargalesis is an exhilarating scientific puzzle with far-reaching implications for developmental, sensorimotor, social, affective, clinical, and evolutionary neuroscience.

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36. Ruth Knight

Title: Hearing everybody: using coproduction in body image research

Full authors list: Ruth Knight, Georgie Burton

First author affiliation: York St John University

Keywords: body image, coproduction, diversity

Abstract: Body image disturbance, including body dissatisfaction and experiences of disordered eating, are widespread amongst the general population and across different communities. Despite this, research in the area typically focuses on a narrow subset of participants and adopts an approach driven by the research, not by the relevant communities (Halbeisen et al., 2022). In order to generate useful data and meaningful conclusions, the onus is on us as researchers to diversify not only the questions we ask, but also who we ask them of and how we ask them. Using coproduction is one way of doing this (Ayton et al., 2025). This presentation will outline lessons learnt across three projects that explored body image using coproduction principles to different extents; one considering disordered eating in non-binary participants, another looking at body image in disabled participants, and a third that explores multiple intersecting marginalized identities and how they influence body image. We will outline the peaks and pitfalls of doing this kind of work, including the impact on methods used, data analysis and interpretation, and dissemination. Suggestions for developing best practice will be considered including payment issues, accessibility and engagement, and shared responsibility. Involving communities in research is a vital first step to developing a more accurate and representative account of body representation across multiple different domains, but it is not without challenge. By sharing and discussing these experiences we hope to challenge fellow researchers to adopt similar approaches and meet head-on the responsibility of ethical and effective body image research.

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37. Arina Schippers

Title: Embodying exoskeletal fingers changes their perceived weight

Full authors list: Arina R. Schippers, Dominika Radziun, Matthew Longo, Luke Miller

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: Weight perception, exoskeleton, embodiment

Abstract: Humans underestimate the weight of their limbs [1], which has been linked to the ability to predict and attenuate weight-related sensory feedback. In contrast, prosthetic limbs are often felt as heavier than actual limbs, even though the prosthetic is usually lighter [2]. The perceived weight of prosthetic limbs decreases when sensory feedback is restored to them, likely due to an increase in their embodiment. To what extent these results generalize to wearable body-augmenting technology is unknown. Using finger-extending exoskeletons as a case-study, we investigated what the effect of their embodiment is on the perception of their weight. In our experiment, participants perceptually judged whether a weight hung from their left arm was heavier or lighter than their right hand, with and without the exoskeletons attached to the right fingers. Perceived weight was determined using QUEST, an adaptive algorithm for determining the point of subjective equality. Crucially, participants performed these tests before and after a training procedure that familiarized them with the exoskeletons. The training consisted of tasks that assessed fine motor and gross motor skills performed with the exoskeletal fingers. As before, we found that participants underestimated their right hand's weight, as well as their hand+exoskeleton weight. Crucially, the post-training hand+exoskeleton weight was equivalent to the pre-training hand-only weight. Removing the fingers did not lead to a change in the weight perception. In total, these results suggest that the exoskeletal fingers became fully transparent once they were learned. These findings highlight the brain's remarkable capacity to adapt to augmentative devices, suggesting that with sufficient training, even non-biological extensions can become perceptually integrated. Understanding this process is essential for designing more intuitive and comfortable assistive and augmentative devices, ultimately enhancing their usability and acceptance in daily life [2].

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38. Sofia Tagini

Title: Affective Touch in Anorexia Nervosa: The Importance of Who is Touching You and the Role of Attachment Dimensions

Full authors list: Sofia Tagini, Giulia Chirchio, Ilaria Bastoni, Valentina Villa, Leonardo Mendolicchio, Gianluca Castelnuovo, Alessandro Mauro, Federica Scarpina

First author affiliation: University of Turin

Keywords: affective touch; attachment style; interpersonal relationships

Abstract: Affective touch plays a significant role in communicating physical and emotional closeness in intimate relationships. The quality of these bonds is influenced by attachment style, with secure attachment linked to satisfying experiences of affective touch, as opposite to insecure and disorganized patterns. Though not consistently, evidence pointed to altered experience of affective touch in eating disorders, in which insecure and disorganized attachment patterns are common.
This study examined both affective touch and attachment style in 18 women with anorexia nervosa compared to 18 healthy women without eating disorders. Using a mental imagery task, we assessed the pleasantness associated with the hand-touch of a significant female person versus a female experimenter, comparing responses to slow (affective) and fast (non-affective) stimuli, alongside a stick (as control). Affective touch across lifespan and main attachment-dimensions were measured with the Tactile Biography scale and the Attachment Style Questionnaire, respectively.
Both groups preferred affective touch over non-affective touch in the imagined scenario with the significant person but not the experimenter. However, women with anorexia nervosa reported greater discomfort with real-life interpersonal touch and exhibited higher levels of attachment-related anxiety and avoidance; crucially, these measures were also related to worse real-life experience of affective touch in healthy participants.
Our findings support the interplay between affective touch and attachment patterns in healthy individuals, while suggesting a more complex relationship in those with eating disorders. Joint investigations of affective touch and attachment style in eating disorders are mandatory, considering their crucial role in mental health.

POSTER ABSTRACTS (July 4th)

1. Jason Khoury

Title: The Role of Early Self-Touch in the Emergence of Goal-Directed Self-Reaching

Full authors list: Jason Khoury, Sergiu T. Popescu, Dominika Burdova, Matej Hoffmann

First author affiliation: Czech Technical University in Prague

Keywords: sensorimotor contingencies, touch, goal-directedness

Abstract: The ability to act upon the world and ourselves in a skillful and goal-directed way does not come for free. Effective actions require intensive, protracted learning during early development. In infancy, sensitivity to sensorimotor contingencies supports this learning, as infants detect and learn co-occurrences between multimodal sensory signals, differentiating those that result from their own actions [1]. Self-touch (touch directed to one's own body) is highly frequent in the first months of life and may serve as an essential foundation for sensorimotor learning [2]. This process could play a crucial role in acquiring coordinated and complex motor skills, such as reaching and grasping, suggesting that early goal-directed actions may emerge from self-touch activity. This study aims to investigate whether spontaneous exploration in early infancy serves as a precursor to the ability to reach specific targets on the body with precision. We analyzed motion, self-touch, and reaching data from four infants, recorded between 2 and 7 months of age. Data extraction was performed both manually and using state-of-the-art computer vision methods. We examined the developmental patterns of self-touch activity and reaching performance in response to tactile stimuli applied to different body areas. We also analyzed motion data to identify markers of goal-directedness and shared properties between self-touch and reaching actions. General Tau Theory allowed the detection of prospective motor control in neonates [3]. We tested whether it can be used to gauge goal-directedness in self-touch activity. We compared performance across two postures: supine and seated. Our preliminary results indicate that self-touch follows a structured developmental trajectory and is mirrored in peripersonal space. We anticipate observing posture-dependent differences in movement characteristics, consistent with sensorimotor contingency theory. If self-touch and reaching movements share common properties and developmental trajectories, early tactile exploration may provide a developmental scaffold for goal-directed actions.

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2. Carmen Lenatti

Title: Body structural representations of the glabrous and hairy skin surface

Full authors list: Carmen Lenatti, Desirée Lopis, Sebastien Alexandre Krienen, Heather Ferguson, Luigi Tamè

First author affiliation: University of Kent

Keywords: Tactile perception, Body Structural Representations, Glabrous and Hairy skin

Abstract: Knowledge about body representation is drawn from different sensory modalities but relies strongly on tactile information. The body structural representation (BSR) is a visuospatial map of the body in which the spatial configuration of different body parts is defined (Schwoebel & Coslett, 2005). Recent evidence has demonstrated that BSR is not fixed but can be dynamically updated by external factors such as changes in body posture (Tamè et al., 2017). However, the extent to which different skin regions (glabrous vs. hairy) modulate access to the structural representation of the hand remains unclear. To address this, we conducted two experiments using an adapted version of the "in-between" test (Kinsbourne & Warrington, 1962), where healthy individuals received tactile stimulations on the fingertips and estimated the number of unstimulated fingers between the two touched ones. In Experiment 1 (N=30), the skin region (glabrous vs. hairy) and hand posture (palm up vs. palm down) were varied across conditions. In Experiment 2 (N=30), hand posture was held constant (palm down), while the stimulated skin region was manipulated. Results showed a significant difference in fingers' numerosity estimation between the glabrous and hairy skin stimulation. Specifically, participants estimated greater numerosity in the glabrous skin condition regardless of hand posture, but this effect was only evident when non-adjacent fingers were stimulated. This suggests that the access to the BSR of the hand depends on the skin surface stimulated and is updated as a function of the anatomical distance between different body parts.

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3. Annika Lutz

Title: Cardio-visual integration of body images: An investigation of visual and heartbeat evoked potentials

Full authors list: Annika P.C. Lutz, Lynn Erpelding, Claus Vögele

First author affiliation: University of Luxembourg

Keywords: multisensory integration, body image, heartbeat evoked potentials

Abstract: Integration of information from different sensory channels forms the basis of the mental representation of one's body. Disruptions in multisensory integration may play a role in mental disorders, such as eating disorders. Most research has focused on the integration of exteroceptive modalities (e.g., visual and tactile), although interoceptive, especially cardiac, information is crucial for the experience of body ownership and self-recognition [1]. Cardio-synchronous presentation modulates the cortical processing of body images [2]. We investigated if this effect differs for one's own vs. another person's photograph, or different cardiac cycle phases, and how it affects the cortical processing of both the visual body image and the heartbeat. Fourty nine normal-weight women saw their own photograph, taken from the back in standardised tight clothing, and the photograph of another participant, matched for BMI. Both photographs were presented in an upright, an inverted, and a scrambled version, and in three cardio-synchrony conditions: an early delay from the R peak of the ECG (230 ms), a late delay (530 ms), and random (900 +/- 200 ms). We recorded a 32-channel EEG. Data analysis is ongoing and includes both visual evoked potentials (VEPs) and heartbeat evoked potentials (HEPs). VEP analysis focuses on the N170, a component sensitive to the processing of human bodies. Previous research has shown cardio-synchrony effects specifically for intact bodies or faces, both on the N170 [2] and on HEPs [1]. Our preliminary analysis (n=18) of the N170 component did not show a cardio-synchrony effect for intact, upright bodies. Analysis of HEPs is ongoing.
Once data analysis is complete, the results will contribute to our understanding of how interoceptive information and visual information about the body are integrated. Possible applications include the aetiology of body image disturbance in eating disorders.

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4. Renee Lustenhouwer

Title: Combing the power of imagination with a loving hand: is tactile imagery more pleasant when it is affective?

Full authors list: Renee Lustenhouwer & Larissa L. Meijer

First author affiliation: Utrecht University

Keywords: tactile imagery, affective touch, CT-optimal

Abstract: Interpersonal, caress-like (slow and light) touch can evoke pleasant sensations. Its beneficial effects include reduced stress, anxiety and pain, and are greatest when touch is provided by a loved-one. The affective touch hypothesis postulates that these effects arise from stimulation of C-Tactile (CT) fibers, which subsequently activate brain regions involved in social and affective processing. The CT-system is optimally stimulated by a light stroking velocity of 3 cm/s. Studies suggest that imagined touch (i.e. tactile imagery) can elicit similar brain activation and pleasant sensations. Imagery of CT-optimal touch may thus offer an effective alternative when direct tactile stimulation is unavailable. However, literature directly comparing perception of CT-optimal touch during imagery and stimulation is scarce and limited to small samples. Moreover, it remains unclear whether individuals can accurately imagine touch at CT-optimal velocities. Here we compared perceived pleasantness of CT-optimal and CT-nonoptimal touch during tactile imagery and stimulation in a sample of healthy adults (n=48, age=21±0.23 years). We additionally recorded imagery times, to investigate whether individuals can differentially imagine slower, CT-optimal (3 cm/s), and faster, CT-nonoptimal (18 cm/s), stroking velocities. Participants first performed tactile imagery of CT-optimal and CT-nonoptimal stroking, followed by equivalent tactile stimulation by an assessor. Overall, pleasantness scores were slightly, albeit significantly, lower for tactile imagery than stimulation. Importantly, CT-optimal touch was perceived as significantly more pleasant than CT-nonoptimal touch, both during imagery and stimulation. Moreover, pleasantness scores for imagery and stimulation were significantly and positively correlated. These findings illustrate the similarities in how (CT-optimal) touch is perceived during imagery and stimulation. Furthermore, participants took significantly longer to imagine CT-optimal than CT-nonoptimal stroking. This suggests that individuals can accurately imagine CT-optimal touch velocities. Our findings further consolidate the overlap between imagery and stimulation in perception of (CT-optimal) touch, and confirm tactile imagery's potential for future clinical applications.

5. Marika Mariano

Title: Me in Action: using VR to explore the interaction between sense of agency and ownership

Full authors list: Mariano M., Stanco G., Negrone C., Massaro F., Sterlicchio A., Gabbiadini A., Salvato G., Zapparoli L.

First author affiliation: University of Milano-Bicocca

Keywords: Sense of Agency, Sense of Ownership, Virtual Reality

Abstract: Bodily self-awareness is a multidimensional construct encompassing both the sense of ownership (SoO), the feeling that one's body belongs to oneself (1), and the sense of agency (SoA), the experience of controlling one's actions (2). The extent to which these cognitive dimensions interact remains an open question. Therefore, the present work explores their potential behavioural interplay through a virtual reality (VR) paradigm designed to systematically manipulate and assess SoO and SoA.
Thirty healthy adult participants performed a temporal estimation task in VR: pressing a button to switch on a light. SoA was manipulated by involving active (self-initiated) vs. passive (externally induced) task-related actions while also introducing variable temporal delays between the action and its outcome. SoO was manipulated by showing participants their virtual hands in an anatomically plausible position (congruent condition) or swapped (i.e., incongruent condition).
To measure explicit SoA and SoO, participants provided self-reported trial-by-trial judgments of agency and ownership. Implicit SoA was assessed by measuring the perceived temporal compression between the action and its outcome, in line with the intentional binding phenomenon (2).
Results demonstrate that both SoO and (implicit and explicit) SoA were stronger in active trials, particularly when the sensory outcome was temporally contingent on the action and when the virtual hands were presented in a biologically congruent manner. This suggests that both agency and ownership manipulations shaped motor awareness.
This study provides novel insights into the behavioural mechanisms underlying bodily self-awareness, highlighting a significant interplay between agency and ownership at multiple cognitive levels when interacting within a (virtual) environment.

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6. Isabella Martinelli

Title: From youth to ageing: changes in hand ownership are driven by proprioceptive precision

Full authors list: Isabella Martinelli, Gaia Risso, Tommaso Bertoni, Valentina Meregalli, Enrico Collantoni, Gabriella Bottini, Michela Bassolino, Andrea Serino

First author affiliation: University of Pavia & HES-SO Valais-Wallis

Keywords: Ownership; Aging; Multisensory Integration

Abstract: The feeling that our body belongs to ourselves, commonly referred to as body ownership, relies on the integration of multisensory signals coming from the world and from the body itself [1]. As the human sensory system undergoes significant transformations throughout life, the current works aims at better characterizing age-related changes in hand ownership from youth to ageing. We recruited 92 healthy, right-handed women (age range: 15-83 years old) and administered them with a virtual reality based visuo-proprioceptive disparity task (VPD) in which they were asked to perform reiterative reaching movements towards a visual target while observing a virtual hand displaced at different disparities from the real hand's position [2]. Proxies of ownership were assessed by collecting reaching errors (implicit) and by asking judgments of ownership toward the virtual hand (explicit). Errors were modelled using a Bayesian causal inference framework in which ownership for the virtual hand resulted from a weighted average between pure visual and pure proprioceptive guidance according to their relative precision, and to the a priori probability that the virtual hand was one's own (prior) [2,3]. At the explicit level, with increasing age participants reported higher ownership ratings toward the virtual hand even when displaced from the real hand position. A similar pattern was found also at the implicit level, as the higher was the age, the higher were the errors, with reaching movements more shifted towards the virtual hand at all disparity levels, except under the congruent condition (disparity = 0°). Finally, when looking at the sensory component underlying hand ownership fitted from the multisensory task, older adults showed higher proprioceptive variability and lower visual variability compared to younger adults, indicating that with increasing age, vision was the most reliable sensory cue during the task. Interestingly, no age-effect was found on the prior. In line with the work by Risso and colleagues [3], these findings extend to a larger age spectrum the finding that changes in hand ownership are mostly driven by progressive decline in proprioceptive precision occurring during ageing. Furthermore, the shift toward visual dominance observed in older participants likely reflects a compensatory strategy to maintain body ownership despite age-related sensory declines.

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7. Jamie Moffatt

Title: Embodiment and adaptation to an extendable arm in children and adults

Full authors list: Jamie Moffatt, Leif Johansen, Claire Yuke Pi, Simon Thurlbeck, Marco Gilles, Sylvia Xueni Pan, Dorothy Cowie

First author affiliation: Durham University

Keywords: Virtual Reality, Embodiment, Movement

Abstract: Virtual Reality (VR) confers the opportunity to experience the body in a way that is markedly differ from one's own and even to enhance its functionality. How can a user embody such a virtual body? We examined the Go-Go technique, which extends the virtual arm, allowing the user to interact with items that are typically beyond reach. We tested how children and adults adapted to this novel visuo-motor control scheme and how it affected their sense of embodiment.

In a first experiment, adults, younger children (5-7 years) and older children (8-10 years) made forward reaching movements to feed a virtual animal in a virtual environment. The virtual arm was either slightly reduced (F-, 80%), slightly increased (F+, 120%) or greatly increased (F++, 400%) in terms of its visual gain and functionality.

Compared to a baseline condition with no visual gain, only adults in the F++ condition felt a reduced sense of ownership over the virtual hand. In addition, following enhanced 'GoGo' experiences participants of all ages judged that they could reach further than at baseline, while these reach affordances were similar under conditions of decreased visual gain.

Reach kinematics showed that all ages adapted well to the new arm, increasing their reach velocity in the enhanced GoGo conditions while also maintaining safely controlled reaches. However, different age groups also found specific movement solutions. For example, while adults showed the same pattern of acceleration and deceleration across baseline and GoGo conditions, children adopted more cautious, longer decelerative phases for F++ conditions. These age-dependent differences in how easily people adapt to an extended virtual arm were present despite similar felt ownership and reach affordance. In a planned second experiment, the reaching task will be used with a training paradigm to test how embodiment of the Go-Go arm may build over time.

8. Hamide Beyza Muhtaroğlu

Title: Recall of Information Learned Through Visual and Tactile Interaction: A Comparison of Virtual Reality and the Real World

Full authors list: Hamide Beyza Muhtaroğlu, Habibe Sena Dündar, Mehmet Akif Güzel

First author affiliation: Abdullah Gül University

Keywords: memory recall, virtual reality, sensory interaction

Abstract: Unlike traditional interfaces, such as keyboards, mice, and mechanical dials, VR immerses the user in the experience. Instead of just looking at a screen, users can interact with a 3D experience. It, therefore, simultaneously simulates as many senses as possible, such as vision, hearing, and touch (Javaid et al., 2024). However, retaining information learned after a VR experience is still controversial compared to real-world interactions. Since we can actively connect our skin to objects, usually with our hands, to recognize objects and their features (Bremner & Spence, 2017), real-world tactile and visual interactions allow for a more direct relationship with the objects being learned, while this interaction in virtual environments may be more limited. Though existing studies contribute to understanding learning and memory in VR, gaps remain. Most studies compare only visual and tactile stimuli in VR without evaluating how this information is remembered in real life, how it relates to real-world learning, or vice versa. However, these studies do not address the effects of this information on memory recall by comparing real-life and VR environments. Therefore, this current study aims to fill these critical gaps in the literature by measuring and comparing memory performance in both virtual and real-life environments while considering cross-modal interactions. This study aims to measure and compare quantitative data related to memory recall, such as the number of objects recalled, the accuracy of feature definitions, and the metamemory levels of the participants for each object. Participants are assigned to experimental groups, each experiencing different conditions (e.g., tactile only, visual only, combined tactile and visual, and VR with or without tactile feedback). By comparing the performance of the different groups, this study examines the effect of each condition on memory. In conclusion, the findings may provide important insights for memory research in virtual reality.

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9. Wendy Plétu

Title: The psychophysiology of human tickle sensations

Full authors list: Wendy Plétu, Anne Hoffmann and Konstantina Kilteni

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: Tickle, Valence, Arousal

Abstract: Laughter is a common response to tickling, yet it does not always indicate joy, as the sensation can be both enjoyable and reflexively unsettling1. As such, reactions to tickling can be ambivalent, ranging from seeking this interaction to avoiding it and trying to escape from the tickler, suggesting both positive and negative emotional valence2. No study has systematically examined the emotional impact of this interaction alongside its associated behavioral and physiological responses. Using a haptic device designed to elicit tickling-like sensations on the foot soles, this study will investigate the emotional experience of ticklish sensations in healthy subjects. Specifically, we will assess two dimensions of emotions: valence (i.e., whether it is pleasant or unpleasant), and arousal (i.e., whether it is arousing or not)3. We will gather participants' explicit ratings on stimuli ticklishness, pleasantness, unpleasantness, and arousal levels. These ratings will be combined with implicit physiological measures- electrodermal activity, heart rate, respiration, facial electromyography- and behavioral observations (i.e. laughter, and facial expression) to provide a comprehensive analysis. Building on prior findings, we expect a positive relationship between arousal ratings, ticklishness ratings, and physiological measures (i.e. skin conductance response, heart rate, and respiration). In terms of valence, we anticipate more complex and varied associations. Given the subjective nature of ticklishness, we expect that pleasant and unpleasant ratings will differ across individuals. Indeed, stimuli perceived as highly ticklish may elicit laughter/smiling responses but they might not be associated with a high pleasantness rating. Thus, rather than a simple binary classification of tickling as pleasant or unpleasant, we predict that ticklish sensations may exist along a spectrum of emotional experiences. This study aims to deepen our understanding of the psychophysiology of tickling whilst contributing to research on tactile-emotional interactions and providing insights into its evolutionary and social significance.

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10. Dominika Radziun

Title: Neurophysiological effects of training with a finger-extending exoskeleton: An EEG study

Full authors list: Dominika Radziun, Valeria C. Peviani, Luke E. Miller

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: body augmentation, tactile localization, EEG

Abstract: The human brain exhibits remarkable adaptability in integrating novel technological augmentations into its spatial representation of the body. This study investigates how training with a finger-extending exoskeleton affects neural processing of tactile stimuli, with a particular focus on electrophysiological changes in somatosensory processing. Our finger-extending exoskeleton, which is a 3D-printed structure elongating the fingers of the right hand by 10 cm, has previously been shown to induce rapid proficiency in use and influence tactile localization on one's own hand. However, the neural mechanisms underlying this adaptation remain unclear.

Using electroencephalography (EEG), we aim to examine event-related potentials (ERPs) associated with somatosensory processing before and after exoskeleton training. The study follows a three-day protocol: (1) baseline EEG recordings during tactile stimulation, followed by initial training and post-training EEG recording; (2) a behavioral training session without EEG; and (3) a repetition of the Day 1 protocol to assess training effects over time. Tactile stimulation is applied to the index and middle fingers using solenoids, with a control condition involving stimulation of the untrained hand. Participants perform a tactile detection task while EEG is recorded, allowing for an analysis of somatosensory ERP components.

We hypothesize that training with the exoskeleton will lead to measurable changes in ERP amplitudes and latencies, reflecting neural adaptation to the augmentation. Specifically, we predict that increased exoskeleton exposure will enhance integration, resulting in stronger modifications in early somatosensory responses. By examining the neurophysiological basis of exoskeleton adaptation, this study provides insights into how technological augmentations interact with body representation and sensory processing.

11. Wiktoria Rabińska

Title: Developing a Virtual Reality Simulation – How Design Choices Shape Virtual Embodiment, Immersion, and Presence?

Full authors list: Wiktoria Rabińska, Artur Gunia

First author affiliation: Jagiellonian University

Keywords: virtual reality, misinformation, presence

Abstract: Introduction: Virtual Reality (VR) environments are designed to evoke a sense of presence – the subjective experience of "being there" – along with virtual embodiment and immersion, which shape users' perceptions of themselves and their surroundings within the virtual space [1, 2]. Previous research highlights the importance of specific design elements, such as perspective, multimodal engagement, and environmental realism, in enhancing these experiences [3]. However, little is known about how these factors shape embodiment and presence in the absence of a visible virtual body.
Methods: This study presents a first-person VR simulation developed for use in post-event misinformation research. The simulation consists of two phases: (1) a three-minute walk through a simulated New York street, followed by (2) a critical incident in which a child is abducted outside an ice cream shop. The primary objective is to examine how design choices influence presence, embodiment, and immersion, and to assess the simulation's efficacy as an experimental tool for studying post-event misinformation effects. Thirty participants will engage with the simulation and complete three validated measures: the Igroup Presence Questionnaire (IPQ) to assess presence, the Immersion Questionnaire, and the Acceptance and Control subscales of the Virtual Embodiment Questionnaire (VEQ) to evaluate embodiment-related factors.
Results: Data collection is scheduled for May 2025, with analysis planned for June 2025. Findings will be presented at the BRNet conference.
Discussion: This research will provide valuable insights into the cognitive and perceptual mechanisms underlying presence and embodiment in VR, even in the absence of a virtual avatar. The results have implications for the development of ecologically valid VR-based methodologies, particularly in forensic psychology, where reliable tools for assessing susceptibility to misinformation are essential for evaluating the credibility of eyewitness testimony.

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12. Gaia Risso

Title: The impact of attentional focus on body perception of patients with functional motor disorders

Full authors list: Gaia Risso, Ayla Gay, Marie Bonjour, Martin Sattelmayer, Michela Bassolino

First author affiliation: HES-SO Valais Wallis

Keywords: Functional Motor Disorder; Attentional Focus; Proprioception

Abstract: Despite the absence of organic damage, functional motor disorders (FMD) have a profound impact on patients' lives. A well-known hypothesis proposes that FMD symptoms arise from an imbalance between top-down factors (beliefs, expectations, attention) and bottom-up sensorimotor processing. This imbalance, particularly when attention is focused on one's own body (i.e. internally focused), may exacerbate symptoms. This hypothesis aligns with the FMD experts' consensus which advocates for minimizing internally focused attention during rehabilitation2. To validate this hypothesis, quantitative investigations on how attentional focus influences sensorimotor processing in FMD are still needed.
In this direction, we specifically aim to unveil the impact of internally focused attention (top-down) on perceptual processing of bodily information (bottom-up) in FMD. To do so, we used a proprioceptive task—judging the amplitude of two successive upper-limb passive movements—under two attentional foci (internally vs. externally oriented). Responses were used to fit psychometric curves and compute discrimination thresholds (JND).

We tested 20 healthy controls (HC) and 4 FMD patients. HC showed no differences between internal and external focus of attention. Intriguingly, FMD revealed similar JND to HC when attention was externally oriented. However, performance worsened dramatically when attention was internally oriented, with patients' score exceeding at least the 89% of HC score. These findings support the initial hypothesis, indicating poorer sensory processing in FMD when attention is directed internally. We are extending those findings by adding two other conditions involving respectively only visual (V), and visuo-proprioceptive (VP) information in HC and FMD patients. We aim to evaluate participants' multisensory integration abilities using the gold-standard Maximum Likelihood Estimation model3. Data acquisition is ongoing and preliminary results on 10 HC performing the full P, V and VP experience confirm the absence of differences between conditions under different attentional focus.

13. Julien Russ

Title: Does EMG afford superior control of an extra robotic body part?

Full authors list: Julien Russ, Lucy Dowdall, Francesco Cenciarelli, Kitty Goodridge, Mabel Ziman, Hristo Dimitrov, Dani Clode, Tamar Makin

First author affiliation: University of Cambridge
Keywords: Supernumerary Robotic Finger, Motor Learning, Motor Augmentation

Abstract: Supernumerary robotic fingers (SRFs) offer a novel approach to human augmentation, yet their control remains a challenge. Electromyography (EMG) has been proposed as an intuitive interface by leveraging existing muscle activity. This study investigates whether EMG provides a more effective control strategy compared to force sensing resistor (FSR) control that instead utilizes toe movements for operating a supernumerary robotic finger—the Third Thumb. We evaluated initial skill levels, skill acquisition, and cognitive load across both control modalities in a within-subjects, counterbalanced design with 24 participants.

Participants completed a structured task battery assessing motor coordination and learning with the Third Thumb, measuring performance improvements and cognitive load. Results indicated that FSR control consistently outperformed EMG across all tasks, showing higher success rates and precision. However, both modalities exhibited similar learning rates, demonstrating that EMG can be learned effectively despite its lower initial performance. Cognitive load did not significantly impact performance for either control method, indicating minimal attentional demands. However, we observed a control order effect: while both control modalities showed some generalization, EMG training facilitated stronger skill transfer to FSR control compared to the reverse. This generalization effect was explained by a stronger correlation between control signals while participants were performing with EMG.

This raises the question of whether EMG is inherently inferior as a control modality, or whether its potential was limited by the specific signal parameters extracted in this study. A backward regression model identified key EMG parameters that correlated with both FSR and EMG performance, underscoring the potential of EMG signals for control. Together, these findings demonstrate that multiple control opportunities exist and that as long as biological movement is utilized, control remains accessible to the user. However, more thoughtful approaches are needed to harness EMG effectively for real-time control.

14. Linda Sangalli

Title: Where is my hand? The interaction between verbal manipulation and visual information in shaping one's perceived body location

Full authors list: Linda Sangalli, Francesca Frisco, Vito Bruno, Daniele Luigi Romano, Giorgia Tosi

First author affiliation: University of Milan-Bicocca

Keywords: Body location, verbal manipulation, visual exposure

Abstract: The perceived location of one's body arises from the integration of multisensory inputs [1]. However, body illusions (e.g., Rubber Hand Illusion) [2] could alter our body perception, by shifting the perceived hand position towards the Rubber Hand (i.e. Proprioceptive Drift). Here, in two experiments we aimed to examine the role of verbal conditioning and visual exposure to a virtual Rubber Hand in affecting one's perceived body location [3].

Participants were exposed to four conditions: a baseline assessment; a verbal manipulation, when a shift of participant's hand towards the right was announced but did not happen; a control, when no change of position was advised; and a real shift, when the shift occurred. In the first experiment, participants did not receive any visual input; in the second experiment, participants saw a virtual hand misaligned from the participant's limb (i.e., 18 cm towards the right). After each condition, we assessed the perceived hand position through a body localization task (BLT; i.e., participants pointed at the hands' perceived location in a virtual environment) and a Likert Scale (i.e., participants reported the perceived location relative to a marker).

We conducted two Bayesian ANOVAs, comparing the shift perceived in the implicit (BLT) and the explicit (Likert Scale) outcomes across the two experiments (between-subject factor "Experiment") and Conditions (within-subject factor). The best model for the Likert Scale reveals Condition and Experiment main effects (BF10=4.645*10+27); the best model for the BLT also includes their interaction (BF10=2.743*10+43), implying that the visual exposure influences change through conditions.

Our results reveal that verbal manipulation can impact the explicit perceived body position, irrespective of visual exposure, while the implicit percept is manipulated only when participants are exposed to the visual information, suggesting that the combination of multiple sensory sources is needed to affect one's implicit perceived body location.

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15. Gerardo Salvato

Title: The contribution of cutaneous thermal signals to bodily self-awareness

Full authors list: Gerardo Salvato, Paul Mark Jenkinson, Manuela Sellitto, Damiano Crivelli, Francesco Crottini, Teresa Fazia, Silvia Amaryllis Claudia Squarza, Mariangela Piano, Maria Sessa, Martina Gandola, Aikaterini Fotopoulou, Gabriella Bottini

First author affiliation: University of Pavia

Keywords: ownership, temperature, stroke

Abstract: Thermosensory signals may contribute to the sense of body ownership, but their role remains highly debated. We test this assumption within the framework of pathological body ownership, hypothesising that skin temperature and thermoception differ between right-hemisphere stroke patients with and without Disturbed Sensation of Ownership (DSO) for the contralesional plegic upper limb. Patients with DSO exhibit lower basal hand temperatures bilaterally and impaired perception of cold and warm stimuli. Lesion mapping reveals associations in the right Rolandic Operculum and Insula, with these regions linked to lower skin temperature located posterior to those associated with thermoception deficits. Disconnections in bilateral parietal regions are associated with lower hand temperature, while disconnections in a rightlateralized thalamus-parietal hub correlate with thermoception deficits. We discuss the theoretical implications of these findings in the context of the ongoing debate on the role of homeostatic signals in shaping a coherent sense of body ownership.

16. Juliane Schubert

Title: Towards a representational body space based on active somatosensing

Full authors list: Juliane Schubert & Xaver Fuchs

First author affiliation: Paris Lodron University Salzburg

Keywords: Somatosensory, Representational Similarity, Body Map

Abstract: The brain is not an isolated entity but rather a part of a bodily organism that thinks, feels, and behaves as a whole. Thus, in order to gain a more holistic understanding of cognition and (self) consciousness it is important to consider the phenomenological aspects of the body, as suggested by Gallagher (2005).
Cortical activity related to peripheral motor activity, such as ocular movements, has often been disregarded as artifactual but has shown to considerably contribute to perception and cognition in the context of active sensing and embodied experience (e.g. Gehmacher et al. 2024, Schubert et al. 2024). However, the somatosensory modality has, so far, received little attention in this regard.
Using magnetoencephalography (MEG) we record brain activity in response to active (self-touch) as well as passive (pneumatic) somatosensory stimulation distributed over different body parts, ranging from foot to cheek. This enables us to describe different body parts based on their (dis)similarities and investigate somatosensory experience within a representational space. By comparing neural responses to perceptual and conceptual models of body representations we aim to build an active somatorepresentational body map. We argue that this body map is a fundamental basis as well as a consequence of perceptual experience as it shapes the cognitive and cortical landscape.

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17. Manuela Sellitto

Title: Focusing attention on bodily signals could reduce impulsive food choices

Full authors list: Manuela Sellitto, Gabriella Bottini

First author affiliation: University of Pavia

Keywords: Food reward; interoception; self-control

Abstract: It has been suggested that overeating and obesity may arise from the inability to accurately detect interoceptive signals of satiety as well as to hypersensitivity to edible cues, resulting in increased impulsivity toward food (e.g. Robinson et al., 2021; Simmons and De Ville, 2017).
Here we tested whether focusing attention on internal, bodily signals could reduce impulsive food choices.
We preliminary tested N=54 healthy young adult volunteers, assigned randomly to two matched groups. The experimental group underwent to a task requiring focusing attention on internal bodily signals, whereas participants in the control group underwent to a control task, focusing attention on external cues. Immediately after, participants in both groups made a series of choices between immediate and delayed amounts of food and between immediate and delayed amounts of money, as measures of self-control. Afterwards, participants filled a series of questionnaires investigating interoceptive ability, anxiety, and body satisfaction.
We found that participants in the control group made significantly more impulsive choices when facing food rewards than monetary rewards, consistent with a large body of previous evidence (e.g. Schiff et al. 2016). Conversely, participants in the experimental group made a statistically comparable number of impulsive choices between food rewards and monetary rewards. Exploratory analyses suggested that, in the experimental group, especially participants with high interoceptive accuracy became apparently as self-controlled during food choices as when facing monetary rewards. These results emerged in the absence of differences between groups on BMI, current hunger level, interoceptive accuracy and sensibility, and body satisfaction.
The present findings, emerged within the European Union-funded MNESYS project, hint at the possibility that focusing on internal, bodily signals prior to making decisions about food may help heightening the ability to resist to immediate gratification.

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18. Oscar Sill

Title: Structural Body Representation Accuracy Develops Throughout Life

Full authors list: Sill, O. J., Kentridge, R. W., & Cowie, D.

First author affiliation: Durham University

Keywords: Structural representations, Childhood, Development

Abstract: Accurately representing one's own body structure is a critical facet of everyday life, influencing how we perceive ourselves and interact with the surrounding world. For adults, maintaining a consistently accurate set of representations may seem intuitive, but for children, whose bodies are constantly growing and changing, the process of building and maintaining coherent structural representations may be challenging.

To investigate this, we tested children (n= 25; 5-10yrs) and adults (n= 39; 18-42yrs) on a structural body representation mapping task, adapted from Caggiano and colleagues' work in adults (2020, 2021). In this task, participants imagine their body standing in front of them and point with a laser pointer to 14 locations across the imagined body. These points are recorded using 3D motion capture and combined to form a 2D 'map' of perceived body layout. The perceptual map is then compared to maps of the participant's actual body structure, giving error rates for perceived measurements across the body. Control responses for non-body visuospatial estimation (e.g. visualising an A4 piece of paper) can then also be measured and accounted for.

Across this study, we find widespread and striking patterns of structural body representation error. Firstly, we find significant developmental shifts, in that children possess significantly greater error than adults across the whole body combined ($p=.001$), and overestimate their hip width ($p<.001$), shoulder width ($p<.001$), and torso height ($p<.001$) to a significantly greater degree than adults. Interestingly however, children are also equivalent to adults in overestimating lower leg length and upper arm length, and under-estimating upper leg length and lower arm length (all $p<.001$ vs perfect accuracy).

Overall, this work suggests that structural body representations may develop in a nuanced manner, with distinct trajectories for individual areas of the body and with development taking place well into late childhood.

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19. Maura Simioni

Title: Body Ownership alterations induced by Intracerebral Electrical Stimulations in the left insula and right frontal operculum: a case report

Full authors list: Simioni Maura, Pelliccia Veronica, Toraldo Alessio, Peluzzi Alessandra, Peretto Chiara, Scarpa Pina, Castana Laura, Squarza Silvia Amasyllis Claudia, Tassi Laura, Bottini Gabriella, Gandola Martina

First author affiliation: University of Pavia

Keywords: Body Ownership, Intracranial Electrical Stimulations, Drug-resistant epilepsy

Abstract: Introduction: Body Ownership (BO) alterations have been mainly studied in acute brain-damaged patients [1], with only isolated accounts of BO alterations induced by Intracerebral Electrical Stimulations (IES) in patients with drug-resistant epilepsy [2]. Here we studied BO alterations induced by IES in the left insula and right frontal operculum in a right-handed patient with right-insular epilepsy, who underwent stereo-EEG.
Methods: High-frequency IES (frequency 50Hz, intensity 2-3mA, duration 5sec, pulse width 0.5msec) were delivered to four sites in the left insula and one in the right frontal operculum. BO alterations and other bodily-related phenomena were investigated with an ad-hoc questionnaire involving Visual Analog Scales (VAS). We aimed at testing if specific symptoms were linked to specific sites and if stimulation intensity could modulate perceived symptoms' intensity. Six theoretically driven Bayesian Generalized Linear Models (Tweedie distribution, log-link) that combined Site, Question, and Intensity as predictors and had VAS score as dependent variable were estimated. Models were compared using WAIC. Results: Stimulation of the left insula and the right frontal operculum evoked alterations of ownership and misperceptions affecting the contralateral hand. From a qualitative point of view, a posterior-anterior gradient emerged among insular sites, with posterior sites leading to stronger symptoms. Bayesian analyses (WAIC) selected the model including Site, Question, Intensity, Site*Question, Site*Intensity and Question*Intensity as predictors, as the best one, suggesting that specific symptoms are evoked by the stimulation of specific sites, with stimulation intensity modulating perceived symptoms' intensity. Discussion: Despite their exploratory nature, our findings provide significant contributions to the existing literature, corroborating the role of posterior insula in BO [3] and providing remarkable new evidence on the role of the left hemisphere in BO.

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20. Maggie Szymanska

Title: Expecting Pain: How Individuals with Phantom Limb Pain Integrate Sensory Evidence

Full authors list: Szymanska, M. & Dimitrov, H., Root, V., Mancini, F., Makin, T.

First author affiliation: University of Cambridge

Keywords: pain, amputation, learning

Abstract: Phantom limb pain (PLP) is a prevalent yet poorly understood neuropathic condition following limb amputation. Research has predominantly focused on cortical explanations, leaving the roles of cognitive and peripheral processes less explored. This study investigates how individuals with PLP integrate sensory evidence to shape pain expectations. We hypothesize amputees will show impaired learning, due to more rigid expectations and dissociation between movement and sensory experience, with greater deficits in those experiencing higher PLP.

We employed an aversive learning paradigm where individuals with and without an amputation associated visual cues with painful or non-painful thermal stimuli. Task 1 involved three cues linked to hot, warm, or random stimuli, with expectancy, pain ratings, and electromyography recorded across passive (no movement) and active (phantom movement) conditions. Task 2 had two cues, with a high (volatile) and low (stable) contingency switch rate conditions (expectancy recorded). Reinforcement learning models will quantify trial-by-trial expectancy updates to assess individual differences in pain-related decision-making.

Descriptive preliminary control data suggests successful learning in both tasks. In task 1, controls shows better learning in the passive condition, which we believe will be amplified in the amputee group. Expectancy biases are present in controls but are expected to be stronger in PLP participants, who may overestimate pain for innocuous stimuli. Phantom movements could further amplify these biases. In Task 2, controls adapt well to stable contingencies but struggle with volatile ones. We predict amputees will have even greater difficulty with volatility due to more rigid association formation from their pain experience.

21. Lucy Stafford

Title: Restrictive disordered eating is related to reduced updating of prospective beliefs about sensitivity to satiation: Preliminary findings from an experimental and computational study.

Full authors list: Stafford, L.; Pike, Alexandra C.; Preston, Catherine E. J.

First author affiliation: University of York

Keywords: interoception; belief updating; eating disorders

Abstract: Background: People with restrictive eating report decreased sensitivity to interoceptive signals (Saramandi et al., 2024). Updating beliefs about our sensitivity to satiation (comfortable fullness) appears important for regulating food intake. For example, if people with restrictive eating are over-reliant on their prior beliefs about being insensitive to satiation cues, they may not trust their body to regulate its energy intake and notice that they have eaten enough. Thus, they then preemptively restrict to avoid what they perceive as overeating, leaving their beliefs unchallenged by actual interoceptive experiences. As research has yet to do so, the aim of this study was to investigate the contribution of restrictive eating to belief updating for sensitivity to satiation. Methods: In a pilot sample of 5 participants, measures of belief and confidence regarding sensitivity to satiation before, during, and after a Water Loading Task (van Dyck et al., 2016) were collected. This task manipulates fullness via water consumption by instructing participants to drink to satiation and then complete fullness. Actual sensitivity to satiation is indexed by Sat%, the amount drunk to satiation relative to complete fullness. The Eating Disorder Examination Questionnaire-6 (Fairburn & Beglin, 2008) measured restrictive eating. Results: In our preliminary analysis, we fitted four Bayesian Belief Updating models, and model comparison showed the best model incorporated belief during task as evidence and confidence in this belief as the best precision of evidence. Linear regression models suggest increases in restrictive eating predicts decreases in prior beliefs about sensitivity to satiation (β=-3.339), Sat% (β=-5.131), and learning rate (β=.-008). Discussion: People who restrict their food intake may be more reliant on their pessimistic prior beliefs rather than their, albeit perhaps reduced, interoceptive experience of sensitivity when updating their beliefs about their sensitivity to satiation. Further testing is planned to extend these results.

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22. Giulia Stanco

Title: How acting using a tool shapes the implicit sense of agency in the near and far space

Full authors list: Giulia Stanco, Marika Mariano, Eleonora Cracolici, Laura Zapparoli

First author affiliation: University of Milano-Bicocca

Keywords: Sense of agency, Spatial representation, Body representation

Abstract: The experience of controlling our actions and their consequences in the external world is defined as Sense of Agency (SoA) [1]. An indirect index used to assess the implicit agency experience is the intentional binding phenomenon (i.e., the perceived time compression between a voluntary action and its outcome [2]). In a recent study, we showed that spatial cues may modulate this experience: participants perceived a stronger implicit agency experience for sensory consequences that occurred near them [3]. Here, we further explore this topic by investigating whether such spatial modulation may be influenced by extending the individuals' peripersonal space.

We studied 41 healthy adults while they actively or passively pressed a button to turn on a switched-off lightbulb, that went on after a variable delay (200, 400, or 600ms). Participants were invited to estimate the perceived time interval between their button press and the lighting of the lightbulb, to measure the intentional binding phenomenon. Importantly, the lightbulb and the corresponding button might be placed near or far from the subjects. Both buttons were pressed using a specific tool, which allowed us to expand the participants' peripersonal space.

Participants showed a similar implicit agency experience for outcomes appearing in the near and far space when the action-outcome temporal delay was 200ms. These results provide further evidence of the intentional binding phenomenon and highlight the crucial role of temporal cues: we feel more responsible when there is a temporal contingency between our active action and its consequences. Interestingly, we did not observe a reduction in implicit agency for outcomes occurring in far space, as reported in our previous study [3]. We suggest that the tool may have effectively extended participants' peripersonal space, thereby broadening the area in which they experience a sense of control over the outcomes of their actions.

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23. Tilman Stephani

Title: Determinants of tickle: stimulus characteristics and neural correlates

Full authors list: Tilman Stephani, Ziliang Xiong, Konstantina Kilteni

First author affiliation: Donders Institute for Brain, Cognition, and Behaviour

Keywords: tactile perception, EEG, foot

Abstract: What makes a touch ticklish? Current theories stipulate that tickle reflects a discrete and ambivalent sensation tightly coupled to a drive to convulse and laugh. It arises when another person applies fast and strong repetitive pressure on specific areas of our body, such as the armpit, sides of the trunk, or the foot soles. However, the systematic characterization of stimulus features determining ticklish touch, as well as its representation on a neural level remains elusive. To fill this gap, we explored in three experiments (N=36) how perceived ticklishness depended on velocity and force of repetitive stroking stimuli applied to different areas of the foot soles with a haptic robotic device. Furthermore, we collected multimodal physiological responses, including vocalizations, facial expressions (video analysis), heart rate, respiration, and skin conductance across the three experiments. Results revealed an inverted U-shaped relationship between velocity and ticklishness, with moderate velocity (15 cm/s) rated as most ticklish. This pattern held true for different forces, yet with the additional effect that higher forces increased ticklishness further. Taking full advantage of our rich multi-modal and single-trial dataset, support vector machines (SVMs) were able to predict high ticklishness trials based on the physiological reactions only. To establish a comprehensive neuro-physiological model of tickle perception, a follow-up study probes the neural dynamics of ticklishness using electroencephalography. Preliminary data suggest that ticklish and non-ticklish stimuli differ already at early processing levels, yet further time-frequency analyses and poke-evoked responses are used to examine the entire time course of a ticklish touch´s build-up. Together, the findings do not only provide novel insights into the determinants of ticklish touch – both at the level of stimulus characteristics and neural correlates – but may also inform future studies that test self-tickle cancellation, a sensorimotor interaction that is altered in several psychiatric disorders, such as schizophrenia and autism.

24. Karunya Srinivasan

Title: Body illusions changing assessment of affordances, body perception, and motor behaviour

Full authors list: Karunya Srinivasan, Salvador Soto-Faraco, Elena Marquéz Segura, Ana Tajadura-Jiménez

First author affiliation: Universidad Carlos III de Madrid

Keywords: Multisensory perception, Motor Behaviour, Affordances

Abstract: Affordances – possibilities for action – arise from the complementarity of an organism's action capabilities and its environment. This relationship involves the simultaneous perception of the external surroundings and one's own body and its capabilities. For example, people rely on body-scaled information to estimate whether they can pass through apertures straight on (e.g., without turning their shoulders), typically at the critical ratio of aperture width 1.3 times their shoulder width(1). Critically, one's body perception is highly malleable, constantly updated by sensorimotor input and top-down cognitive body models(2). While changes in mental body representation (MBR) have been explored in both healthy individuals and clinical populations, their impact on affordance perception and motor behaviour remains less understood. How does an altered sense of body size influence a person's actions and interactions with the environment? Patients with anorexia nervosa, who overestimate their body size, rotate their shoulders to pass through apertures much wider than the critical ratio(3). To investigate whether similar behaviour changes occur in healthy participants experiencing a temporary alteration in body representation, we will use sensory stimulation to induce the illusion of a wider or narrower body. We will assess affordance perception and action in three body illusion conditions (wide, narrow, and control) through two tasks: 1) aperture passability judgement – estimating when one can fit through a gap formed by sliding panels; and 2) aperture crossing – participants pass through different sized apertures while motion-tracking technology captures their shoulder rotation. At the conference, we will present our protocol and initial findings to discuss our ongoing research. By examining whether temporary induced perceived body changes translate into altered affordance judgments and motor behaviour, this study will offer novel insights into the interplay between body representation and action, with potential implications for understanding disorders involving body image distortions.

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25. Chatrin Suksasilp

Title: Interoceptive training reduces anxiety and increases Bayesian precision weighting of cardiac signals

Full authors list: Chatrin Suksasilp, Ryan Smith, Sarah N Garfinkel

First author affiliation: University College London

Keywords: Interoception, training, Bayesian

Abstract: Perceptual accuracy for interoceptive signals, such as heartbeats, varies in a trait-like manner across individuals and may influence the capacity for emotion regulation and vulnerability to affective symptoms, notably anxiety. We present data indicating that training individuals to more accurately perceive heartbeats also reduces anxiety, in both neurotypical and autistic adults. Bayesian computational modelling indicated that accuracy improvement in the heartbeat discrimination task was associated with increases in the internal reliability estimate for interoceptive signals – their precision weighting – informing mechanisms of action and treatment response.

26. Sofia Tagini

Title: Affective touch in obesity: who touches you does it matter?

Full authors list: Tagini Sofia, Scacchi Massimo, Mauro Alessandro & Scarpina Federica

First author affiliation: University of Turin

Keywords: affective touch; obesity; attachment style; interpersonal relationships

Abstract: Affective touch plays a crucial role in expressing physical and emotional closeness in intimate relationships, which are characterized by an individual's attachment style. Secure attachment is linked to more frequent and satisfying touch experiences, while insecure patterns are associated with less positive touch experiences. Obesity is often related to attachment insecurity, and we previously showed that individuals with obesity reported less early interpersonal touch than healthy controls. However, their experience of affective touch in a laboratory setting, such as the touch from an experimenter, seemed preserved.

Real-life affective touch occurs primarily within intimate relationships, so we proposed that experimental settings should involve meaningful individuals rather than strangers. This study compared 18 women with obesity to 18 healthy controls, using a mental imagery task to assess the pleasantness of touch from a significant person versus an experimenter. Participants evaluated slow (affective) and fast (non-affective) touch stimuli, along with a stick as a control.

Both groups preferred affective over non-affective touch, but this preference was more pronounced when considering touch from a significant person. These findings support previous evidence that individuals with obesity can preserve the experience of affective touch in controlled settings. The study emphasizes the importance of using "real" affective contexts in research. These results will be discussed in the light of evidence about the expression of attachment-dimensions in our participants since we argue they may play a crucial role, especially when involving intimate people.

27. Giorgia Tosi

Title: The rubber hand illusion questionnaire: An exploratory graph analysis of ownership, referral of touch, and control statements

Full authors list: Giorgia Tosi; Andreas Kalckert; Anantha Krishna Sivasubramanian; Daniele Romano

First author affiliation: University of Milano-Bicocca

Keywords: Rubber hand illusion; Exploratory graph analysis; Psychometric

Abstract: The rubber hand illusion is a well-known experiment that allows manipulation of one's own body experience. The original questionnaire gauges both the illusion experience and unforeseen experiences acting as control statements. In particular, two statements pertain to the referral of touch originating from the rubber hand (RoT), and one concerns the feeling of ownership of the rubber hand (SoO). Despite its prominence, the rubber hand illusion questionnaire has not undergone a thorough examination of its psychometric properties. The literature reveals a tendency to use RoT and SoO statements interchangeably. In this study, we employed Exploratory Graph Analysis to explore the item structure and compared the correlation between SoO and RoT items in various conditions. While SoO and RoT are closely linked, our findings suggest potential separation. SoO and RoT statements consistently correlate, yet hints emerge that RoT might represent a distinct facet of the illusion. Correlations diminish beyond the perihand space, indicating a nuanced relationship. Additionally, moderate relationships between control statements and those measuring the illusion suggest that even control statements are modulated by the illusion experience. This study underscores the need for further exploration into the psychometric properties of body illusion questionnaires, prompting reflections on the interpretation in light of these results.

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28. Arianna Vecchio

Title: I feel fat: Altered spatial estimates of abdominal limits in adolescents with Restrictive Eating Disorder

Full authors list: Vecchio, A., Peviani, V., Carrara, A., Ghiazza, C., Pagani, F., Fazzi, E.M., Miller, L.E., Medendorp, W.P., Borgatti, R., Mensi, M.M. on behalf of the Mondino Foundation Eating Disorders Clinical and Research Group

First author affiliation: IRCCS Mondino Foundation

Keywords: Proprioceptive localization, Adolescence, Restrictive Eating Disorders

Abstract: Body image disturbances in conditions such as Restrictive Eating Disorders (REDs) represent a consistent predictor of onset, treatment outcome and chronicity. Research showed that overestimation of body weight and disregard for one's body in adult patients diagnosed with REDs are associated with altered tactile acuity and biases in proprioceptive localization, often correlated with symptom severity. It is however unknown whether adolescents with REDs manifest alterations of tactile and proprioceptive processing. This study aimed to characterize possible alterations in tactile and body perception in a sample of adolescent subjects diagnosed with REDs, by comparing their performance with a control population. Patients (N = 49) and age-matched controls (N = 45) were administered with tasks measuring tactile acuity and body landmark localization accuracy on the hand and abdomen. We also explored the relationship between biases in perceptual estimates and levels of body dissatisfaction measured with clinical questionnaires. Our results show increased biases in abdomen proprioceptive localization in the RED group, while biases in hand perception were comparable across groups. We did not find alterations in tactile processing nor statistical relations between tactile acuity, perceptual biases and self-reported body dissatisfaction. Our results indicate that biases in body perception are already present in adolescence, but limited to specific aspects of body perception, such as proprioceptive localization, and salient body parts, such as the abdomen.

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29. Julian van Grondel

Title: Interoception in somatic symptom disorder

Full authors list: J.J. van Grondel, K.J. van der Boom, H.C. Dijkerman, A. Keizer, R. Geenen

First author affiliation: Utrecht University

Keywords: Interoception, somatic symptom disorder, heart rate discrimination

Abstract: Introduction
Interoception, the perception of internal bodily states, is regarded as critical in maintaining homeostasis and self-awareness. Poor interoceptive abilities are often attributed to patients with medically unexplained or persistent physical symptoms, but experimental studies show a mixed picture. This may be partially due to methodological limitations in measuring interoception by prevailing cardiac perception tasks.
Methods
The study examined differences in interoceptive abilities between patients with somatic symptom disorder (SSD) (n = 20) and matched healthy controls (n =18), using the novel Heart Rate Discrimination Task (HRD), the Multidimensional Assessment of Interoceptive Awareness (MAIA-2), and the Body Perception Questionnaire Very Short Form (BPQ-VSF).
Results
Preliminary results show that SSD patients display greater variability in interoceptive accuracy, frequently under- or overestimating their heart rate, while uncertainty and confidence levels were similar to those of healthy controls. Patients scored significantly lower on the Trusting subscale of the MAIA-2, reflecting reduced confidence in bodily sensations. No correlations were found between interoceptive measures and somatic symptom severity.
Conclusion
These findings reflect an increased bias in interoceptive accuracy, where SSD patients might tend to rely more on prior beliefs or assumptions about their internal bodily states rather than on actual sensory input. In addition, factors beyond symptom severity may influence interoceptive deficits. Future research should incorporate diverse measures to better understand the role of interoception in persistent physical symptoms including SSD, hereby contributing to the potential for targeted therapeutic interventions.

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30. Floris van Wettum

Title: Optimal integration of a novel sound-to-space mapping into sensorimotor control loops

Full authors list: F.C. van Wettum, A. El-Gharabawy, W.P. Medendorp, L.E.C. Miller

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: Proprioception, Multisensory integration, Sensory substitution

Abstract: Proprioception is crucial for representing the state of our body and guiding our movements. The importance of proprioception for body representation is evident from deafferented patients and amputees with prosthetic limbs, which currently lack full somatosensory feedback. Whereas the restoration of tactile feedback has seen satisfactory results, the restoration of proprioceptive feedback remains challenging. One possible and underexplored approach would be to restore proprioceptive information via non-invasive sensory substitution. We sought to make initial steps towards this goal, using auditory sensory substitution as a proof of principle that humans can learn new spatial mappings to guide their movements. Participants learned an auditory-spatial mapping to encode the one-dimensional position of a computer cursor through the frequency of an audio tone. After training, they were able to accurately and precisely move an invisible cursor to a visual target using the learned audio-spatial mapping. We then used a multisensory manipulation to evaluate whether they optimally integrate this new sound-to-space mapping into their sensorimotor control loop. Participants again moved an invisible cursor to a visual target, guided by the sound-to-space mapping. About halfway through the movement, we flashed a visual cue (moving dot cloud) that was spatially offset (between -7 to +7 cm) from the sound. We further varied either the spatial spread (Experiment 1) or duration (Experiment 2) of the visual stimulus in attempt to manipulate the level of visual uncertainty and change the relative weighting between vision and sound. In both experiments, we found that participants integrated the visual and auditory spatial information. That is, their responses were biased in the direction of the visual offset. Computational modeling further supported the claim that participants integrated the sound-to-space mapping into the sensorimotor loop. Specifically, endpoint errors and variability could be accounted for by a dynamic multisensory integration model, where sensorimotor control was based largely on auditory feedback during movement. This project demonstrated the learnability and multisensory integration of a novel auditory-spatial mapping, presenting a promising proof of principle for using sensory substitution to encode proprioceptive variables in prostheses.

31. Peter Paul van de Wetering

Title: Exploring the Neural Bases and Mechanisms of Induced Out of Body Experiences: A Literary Review

Full authors list: Peter van de Wetering, Frans Leijten, Chris Dijkerman, Pierre Robe, Martine van Zandvoort

First author affiliation: Utrecht University | University Medical Center Utrecht

Keywords: Out-of-body experiences; Multisensory integration; Brain stimulation

Abstract: Out-of-body experiences (OBEs) involve a sense of detachment from one's physical body, typically due to disruptions in the brain's multisensory integration processes. While significant progress has been made in understanding OBEs, no comprehensive overview exists across various induction methods This systematic review synthesized research on the neural bases underlying induced OBE, considering various induction methods, focusing on the implicated brain regions and underlying mechanisms. A PUBMED and EMBASE database search was conducted using Medical Subject Headings (MeSH) and keywords related to "Impair," "Out-of-body experiences," and "Brain areas." Inclusion criteria required studies on human populations, published in English, reporting on induced OBEs and identifying associated brain regions. Thirteen studies met the inclusion criteria. Of these, seven used electrical stimulation with intracranial electrodes, four utilized transcranial magnetic stimulation (TMS), and two employed hypnosis to induce OBEs. The findings highlight the role of the right temporoparietal junction (TPJ) as central to OBEs, alongside contributions from a broader neural network. The review suggests OBEs arise from disruptions in a complex neural network involving the TPJ. While electrical stimulation is provocative in clinical populations, TMS appears less so in healthy individuals. Individual differences, such as susceptibility to dissociation, may influence OBE occurrence. The findings also raise the question of whether OBEs result purely from sensory integration failures or serve a potential adaptive function.

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32. Shasha Wei

Title: Altered vibrotactile signal combination in patients with chronic hand pain

Full authors list: Shasha Wei, Alex R. Wade, Daniel H. Baker & Catherine E.J. Preston

First author affiliation: University of York

Keywords: Chronic hand pain, somatosensory processing, computational modelling

Abstract: Background: Chronic hand pain is frequently accompanied by diminished tactile acuity, altered hand representation, and modified somatosensory processing—likely reflecting an altered excitatory–inhibitory balance within the primary somatosensory cortex (S1). However, the specific effects of chronic hand pain on vibrotactile processing remain inadequately explored. This study aims to investigate the mechanisms of vibrotactile signal combination in chronic hand pain by assessing vibration thresholds and corresponding brain responses. Methods: Twenty-five individuals with chronic hand pain and 25 age-matched control participants were enrolled in the study. In Experiment 1, vibration detection and discrimination thresholds were determined using a two-alternative forced-choice (2AFC) paradigm under two stimulation conditions (1) 'dekadactyl': all ten digits were stimulated; (2) 'dichodactyl' : a target stimulus was delivered to five digits while a baseline stimulus was applied to the remaining five digits. In Experiment 2, steady-state somatosensory evoked potentials (SSSEPs) were recorded from the digits under three different conditions (1) 'pentadactyl': five digits were vibrated at 26 Hz; (2) 'dekadactyl': all ten digits were vibrated at 26 Hz; (3) 'cross-dichodactyl': 26Hz vibrated five digits and a mask stimulus at 23Hz vibrated the remaining five digits. Results: Patients with chronic hand pain exhibited lower vibrotactile thresholds than controls ($p = 0.05$). Notably, a significant summation effect ($p < 0.001$) was observed at the detection threshold in the chronic pain group but not in controls. SSSEP recordings revealed stronger neural responses in chronic pain patients compared to controls ($p < 0.01$). Computational modeling further indicated reduced suppression effect between digits in chronic pain patients. Conclusion: These findings suggest that chronic hand pain is associated with widespread mechanical sensitisation, and that diminished inhibitory mechanisms may contribute to enhanced neural responses and summation effects. This, in turn, could result in less distinct somatosensory representations for individual fingers, potentially explaining altered tactile perception in chronic pain.

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33. Olga Wódecka

Title: The Effect of Finger Size Distortions on Tactile Temporal-Order Judgments

Full authors list: Olga Wódecka, Krista Overvliet, Anouk Keizer, Chris Dijkerman

First author affiliation: Utrecht University

Keywords: body size perception; MIRAGE illusion; temporal perception

Abstract: Experiencing time (from seconds to days, and even years) is an impressive ability humans have, considering we do not have a sensory organ for time perception (Wittmann, 2009). Still, temporal perception can be highly subjective and can be influenced by different variables, like cognitive factors such as attention (Matthews & Meck, 2016a; Polti et al., 2018). A possible factor in temporal perception that is overlooked in research, is the influence of body perception. Several variables could be important here, like the fact that many sensory signals in our body, e.g. heartbeat, have a temporal component (Wittmann, 2009;). Furthermore, body posture can also influence how we perceive time (Overvliet et al., 2011). Body perception also affects many higher order functions and cognitive processes (Dijkerman & Lenggenhager, 2018). However, the current experiment specifically focuses on changing the body size perception of participants and how that influences their time perception. During the experiment, the appearance of the participants' left index finger is altered to look longer or shorter than in reality using the MIRAGE, a hand-illusion set-up. In the control condition, the appearance of the hand is not changed. The participants took part in a temporal order judgement (TOJ) task, in which they received pairs of short tactile stimuli at the base and top of their (visually altered) finger, with different stimulus onset asynchronies (SOAs). Their task was to report which stimulus came first, and we recorded the accuracy of their responses. We expect that, compared to the control condition, participants will show higher stimulus discriminability (i.e. being able to give a higher percentage of correct responses in shorter SOAs) when the finger is lengthened in the illusion, while shortening the finger will lead to lower discriminability.

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34. Ziliang Xiong

Title: Characterization of human tickling behavior and associated bodily maps of ticklishness

Full authors list: Ziliang Xiong, Konstantina Kilteni

First author affiliation: Donders Institute for Brain, Cognition and Behaviour

Keywords: Ticklishness, social touch, somatosensation

Abstract: Social touch is essential for navigating interpersonal interactions, integrating cognitive, motor, and somatosensory afferent processes. Among its various forms, tickling uniquely triggers laughter and bodily convulsions, typically seen in playful dyadic activities, such as between parents and their children. However, despite its seemingly trivial nature, tickle remains a widely underexplored human behavior. We do not know how tickle relates to tactile experiences, whether it is influenced by cultural or personality differences, and how ticklish sensations are represented on the human body's topography. To address these questions, we performed an online study with 448 participants, aiming for a culturally diverse (149 Chinese, 150 Dutch, and 149 Greek) sample. Participants completed a survey about their experiences as a 'ticklee' and/or 'tickler' during their childhood and adulthood, as well as their opinions on tickling. Additionally, they completed a topographical body-coloring task to indicate body areas related to experiencing ticklish sensations. Our preliminary results revealed that being a 'ticklee' was more common in childhood than adulthood and associated with both pleasant and unpleasant sensations. In contrast, 'tickler' experiences were overall pleasant, indicating a change in perception depending on the behavioral role. Importantly, ticklish sensations were linked to a specific topography, with the neck, armpits, belly, and foot soles identified as the most ticklish areas. Crucially, no cultural differences were found in participants' experiences, opinions, or bodily topography, suggesting a consistent similarity across cultures. These findings provide the first comprehensive characterization of tickle behavior in humans, and indicate that tickling experiences are culturally universal.

35. Fiammetta Zanetti

Title: Implementation of a cardio-visual full-body illusion in Virtual Reality to enhance embodiment and address body image distortion

Full authors list: Fiammetta Zanetti, Johannes G. Herforth, Anton F. Lachmann, Karsten Schönbein, Jean Botev & Annika Lutz

First author affiliation: University of Luxembourg

Keywords: Cardio-visual full-body illusion; Embodiment; Virtual reality

Abstract: Current eating disorder theories suggest patients are locked in a negative and distorted view of their body, not updated by current sensory input. We aim to create a virtual reality (VR) platform to improve body image by targeting multisensory integration. The VR cardio-visual full-body illusion (CVFBI) [1] is believed to enhance embodiment creating an illusory sense of ownership over an avatar through an outline flashing in synchrony with the participant's heartbeat. This induces somatosensory and interoceptive changes hypothesised to affect body image positively. We tested the level of life-likeness required from the avatar to allow the participants to feel embodied in the representation of their own body .A total of 40 participants (50% female) were included in the study. The CVFBI was applied across four distinct types of body representations: a virtual object, a stylized body, a realistic avatar, and a 3D body scan of the participant. In the active CVFBI conditions, the flash was presented with a 200ms delay from the R-peak, whereas in the asynchronous control conditions, it was synchronized with the participant's pre-recorded heartbeat. Embodiment questionnaire [2], electrodermal activity (EDA) and skin temperature (SKT) [3] data were recorded as measures of embodiment. EDA and SKT measurements revealed no significant differences across conditions. However, embodiment scores varied significantly, with more basic body representations (cube, stylized avatar) differing from the more detailed ones (realistic avatar, 3D body scan), which elicited higher embodiment levels but did not differ from each other. Synchronous and asynchronous heart feedback did not produce the expected effects. Our findings suggest that the platform failed to recreate the CVFBI. However, self-recognition did not require a 3D body scan; a realistic avatar based on participant measurements suffices for embodiment. This underscores the need for further research on CVFBI and physiological markers of embodiment, as well as the development of multisensory integration-based interventions for body image disturbances in eating disorders.

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