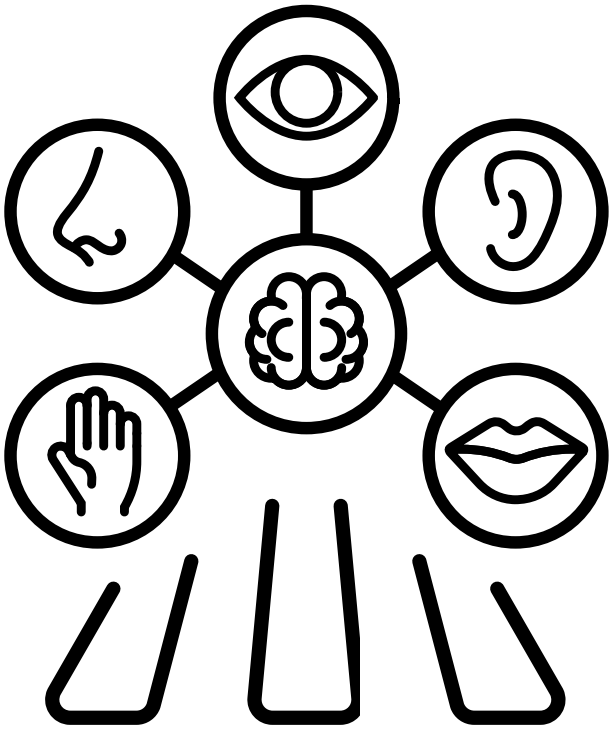
# IMRF

INTERNATIONAL
MULTISENSORY
RESEARCH
FORUM

## BRUSSELS 2023



# POSTERS ABSTRACT BOOK

# POSTER SESSION #1
# JUNE 27 | 7-10 PM

## #001 - Sensation transference from haptics to taste in drinking green tea: The effects of the lip thickness and weight of the glass

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Perceptions of the receptacle can influence taste/aroma/texture judgments of the contents (sensation transference). Numerous studies have reported sensation transference for the haptic dimension of the receptacle. This study was the first to manipulate the thickness of the glass lip to investigate sensory transfer in the evaluations of various drinks contained in the glass with blindfolded participants. Even with identical green tea contents, the thick-lipped, heavy glass enhanced perceptions of the sweetness of the tea compared to the thin-lipped, light glass, while the thin glass enhanced perceptions of the bitterness of the tea compared to the thick glass (Experiment 1). These effects emerged only when the thickness of the glass lip was accompanied by the natural weight (Experiments 1, 4, and 5). The current findings can be interpreted as indicating sensation transference from haptics to taste, where the taste perceptions of green tea were potentiated by the perceived thickness of the glass lip via the association between thickness/roundness and tastes/aromas/texture. However, this glass-lip effect was not observed for beer or red wine, possibly because the current experimental paradigm involving the glass was not suitable for beer or red wine (Experiments 2 and 3). These results suggest that the perceptions of lip thickness and weight of the glass by the mouths and hands can modulate taste evaluations of a beverage, at least green tea.

## #002 - Spatial ventriloquism: audiovisual integration adapts to context dynamically

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In spatial ventriloquism, the perceived auditory location could be biased toward concurrent, neighboring yet task-irrelevant visual stimulus. The Bayesian causal inference (BCI) model assumed the brain had a prior belief which measures how integration of audiovisual events from a common origin could be implemented. Here we used BCI model to directly validate how the binding tendency adapts to the contextual statistics. A random dot visual pattern, with a spatial disparity of either 5° or 20° (Fig1A), was presented in synchrony with a pure tone (50ms, 400-1200Hz, modified with HTRF from the MTI dataset). The 5° audiovisual disparity as congruent condition should lead to ‘integration’ while 20° audiovisual disparity (‘incongruent’) leads to ‘separation’. Moreover, audiovisual consistent (inconsistent) context was given with 70% trials as congruent (incongruent) trials while the remaining 30% as incongruent (congruent). Participants reported the sound location through mouse clicking. With fitted BCI modeling, we found that the binding tendency under the inconsistent context was significantly lower than that under the consistent context (Fig1B), suggesting participants were able to voluntarily shift their binding tendency to adapt to the contextual audiovisual statistics.

## #003 - The Neural Dynamics of Tactile Pattern Integration

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Compared with other sensory modalities such as vision and audition, tactile channel has lower sensitivity and fewer receptors, therefore, it remains a challenge to study the integration of tactile perception. Previous studies have largely revealed the neural mechanism of audiovisual integration, but no direct neural marker of tactile pattern integration has been found. In this study, we employed tactile array of multiple dots (with high spatiotemporal resolution) and developed a new tactile pattern recognition paradigm to explore neural differences in tactile integration of regular and irregular patterns, typically using Steady State Somatosensory Evoked Potential (SSSEP) by frequency tagging. Based on saliency theory, regular patterns can capture more bottom-up attention than irregular patterns. Moreover, irregular patterns are more difficult to comprehensively perceive so they can capture more top-down attention than regular patterns. The results showed that: 1. Both types of tactile patterns integration have specific neural markers; 2. In tactile pattern integration, high-order intermodulation response (high frequency) of SSSEP may represent the high-level cognitive processing for irregular patterns, while low-order intermodulation response (low frequency) may represent the low-level cognitive processing for regular patterns; 3. The early and late stages of tactile pattern integration are driven by bottom-up and top-down attention, respectively.

## #004 - Dynamics of auditory categorization in the brain of sighted and blind

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Early blindness triggers a reorganization in the occipital and temporal brain networks that code for sound categories (Mattioni et al., eLife, 2020 and 2022). However, the impact of visual deprivation on the temporal dynamics of auditory categorization remains unknown. To address this question, we characterized the time course of brain activity using electroencephalography (EEG) while congenitally blind and sighted individuals listened to sounds belonging to eight categories. Preliminary decoding analyses conducted in source space revealed that auditory categories are represented in the temporal and occipital cortices of blind individuals. Ongoing analyses will rely on model-based representational similarity analyses to understand how acoustic and categorical representations of our sounds unfold in time, as well as the spatio-temporal similarities and differences between sighted and congenitally blind individuals.

## #005 - Functional distinction of bimodal audiovisual neurons in the core and belt auditory areas

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The existence of multisensory neurons, key elements in the binding of different sensory modalities, has been shown in different sensory cortices of various animal models such as cat's auditory cortex. A recent study showed that a belt auditory area, the Dorsal Zone (DZ), but not primary auditory cortex (A1) causally contributes to the enhanced visual abilities of deaf cats. Therefore, we hypothesized that visual input influences neurons in area DZ more than A1 in hearing cats which ultimately manifests as stark differences in the role of visual input after deafness. The superior visual properties of DZ could be a result of either the proportion or the function of audiovisual neurons in this belt auditory area. Here we investigated that hypothesis using multiple single-unit recordings from light anesthetized (ketamine) cats, in response to individual and combined auditory, visual, and somatosensory stimulation. We compared the multisensory features of neurons recorded in A1 (n=618) with those identified in DZ (n=482). We found that audiovisual bimodal neurons were the most frequent multisensory response type in A1 (36%) and DZ (53%). However we found no significant difference between the proportion of bimodal neurons, observed in A1 and DZ ($p=0.221$, $n=6$, two-sample t-Test). Furthermore, compared to A1, in the presence of visual stimulation, bimodal audiovisual neurons in DZ, demonstrated faster and more reliable auditory responses. Taken together, these findings suggest the neural mechanisms regarding the influence of visual input on the cortical processing of auditory information.

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

Sally Augustin 1, Cynthia Milota 1

*1 : Design With Science*

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

## #008 - The Contribution of Auditory Imagery to Sensorimotor Synchronization with Visual Rhythm

Fang Jiang 1, Benjamin Sreenan 1, Simon Whitton 1

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Sensorimotor synchronization (SMS) refers to the temporal coordination of an external stimulus with motor movement. Our previous work revealed that SMS to visual flashing patterns, while less consistent than SMS to auditory or tactile patterns, was still evident in a sample of non-musicians. Although previous studies have speculated the potential role of auditory imagery, its contribution to visual SMS performance has not been well quantified. Utilizing a synchronization-continuation finger-tapping task with a visual stimulus that included apparent motion, we aimed to examine how participants’ SMS performance was affected by their auditory imagery ability as well as their musical training and rhythm perception. We quantified participants’ SMS consistency in both synchronization (with visual cues) and continuation (without visual cues) phases. Participants also performed a perception task assessing their ability to detect temporal perturbations in the visual rhythm, and completed musical training and auditory imagery vividness questionnaires. Our linear regression model for SMS consistency included trial phase, auditory imagery vividness, musical training, and rhythm perception as predictors. We found significant effects of trial phase and auditory imagery on SMS consistency, suggesting that participants performed SMS more consistently while the guiding visual stimulus was present, and that the higher one’s auditory imagery ability, the better their synchronization to guided and unguided rhythm. While one’s rhythm perception accuracy and musical training score did not significantly predict SMS consistency, a positive correlation was found between these two measurements. Overall our results confirmed the contribution of auditory imagery to SMS with visual rhythm.

## #009 - Simple shape feature computation across modalities: Convergence and divergence between the ventral and dorsal visual streams

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Shape processing, whether by seeing or touching, is pivotal to object recognition and manipulation. While the low-level visual and haptic signals are initially processed by different modality-specific neural circuits, multimodal responses to object shapes have been reported along both ventral and dorsal visual pathways. To understand this transitional process, we conducted visual and haptic shape perception fMRI experiments to test basic shape features (i.e., curvature and rectilinear) across the visual pathway. Combining univariate activation analysis and support vector machine (SVM) decoding analysis, we found that bilateral occipital cortices (OC) in the ventral visual pathway are involved in the processing of visual shape features, whereas the bilateral posterior parietal cortex (PPC) in the dorsal visual pathway as well as the bilateral middle frontal gyri (MFG) and the bilateral supplementary motor area (SMA) are involved in the processing of haptic shape features. Using a voxel selection method, we found that the top visual-discriminative voxels in left OC could also classify haptic shape features, and the top haptic-discriminative voxels in left PPC could also classify visual shape features, indicating the multimodal representation of shape features in these two regions. Additionally, these voxels could decode shape features in a cross-modal manner, suggesting shared neural computation across visual and haptic modalities. In the univariate analysis, the top haptic-discriminative voxels in left PPC only showed rectilinear feature preference in the haptic modality, whereas the top visual-discriminative voxels in left OC showed no significant shape feature preference in either of the two modalities. Together, these results suggest that mid-level shape features are represented in a modality-independent manner in both the ventral and dorsal streams.

## #010 - Low-frequency activity as a privileged neural support of temporal integration in auditory vs. vibrotactile rhythm

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Humans show a remarkable propensity to move along with musical rhythm. This behavior requires multiscale temporal integration, a key perceptual process to organize fast acoustic events making up rhythmic inputs into larger, behavior-relevant entities such as metrical structures in music. Whether temporal integration is uniformly achieved across sensory modalities, and its underlying neural dynamics, are still unknown. To address this question, we recorded the EEG of volunteers – without moving – and in a separate session, their motor entrainment to the rhythms using finger tapping. We used acoustic or vibrotactile rhythms, given their similar physical characteristics and often-concomitant occurrence in musical contexts. The rhythms were conveyed either by short or long shapes of events. Results showed privileged ability of the auditory system to generate endogenous neural activity representing behavior-relevant perceptual entities such as the meter, in response to acoustic rhythms. This rhythm representation was elicited specifically in a low-frequency range (<10Hz), and enhanced with longer shape of sounds, as was the stability of tapping performance. Although significant neural responses to vibrotactile rhythms were also elicited, this activity spread over a higher frequency range (<25Hz), irrespective of stimulus event shapes. Most importantly, this vibrotactile activity did not exhibit significant representation of behavior-relevant perceptual entities, along with poorer tapping performance. Therefore, the spontaneous ability of the auditory system to generate activity in the low-frequency range may support multiscale temporal integration necessary to behavior-relevant representations of rhythms. In contrast, the somatosensory system faithfully tracks each individual event which may serve discreet perception of the environment.

## #011 - Suppressive bimodal neurons implement a nonlinear weighted average that resembles Bayesian multisensory combination

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We address two multisensory mysteries: (i) what are suppressive bimodal neurons doing and (ii) how do neurons implement Bayesian (Maximum Likelihood Estimation) sensory combinations inferred from psychophysical studies? Despite some psychophysical support, Bayesian MLE reliability (inverse variance) weighted averaging is problematic to implement in wetware. An alternative – nonlinear magnitude-weighted averaging – was suggested by Erwin Schrödinger for binocular perception. We recently identified a class of macaque V1 suppressive binocular neurons that implements nonlinear magnitude-weighted averaging and approximates MLE averaging without the computational difficulties that Bayesian averaging implies. Here we extend this approach to suppressive multisensory bimodal neurons. For visual-tactile (ferret PPr), audio-tactile (ferret AAF), and audio-visual (cat PLLS) stimulation, we find putatively suppressive bimodal neurons that appear to compute magnitude-weighted averaging of multisensory visual firing rates. We find something similar for not-suppressive visual-vestibular neurons (monkey), which as previously reported, have weights that add to more than unity, but modeling this merely requires a normalization constant (which MLE models require anyway in every multimodal case we examined). Although Schrödinger's magnitude weighting is a better fit than reliability weighted averaging for cortical firing rates (in all five cases, in all three species and by both of two criteria), nonlinear magnitude-weighted averaging is well correlated ($r>0.83$ in all cases) with MLE reliability averaging, suggesting that magnitude-weighted averaging could serve as a surrogate for Bayesian neural calculations, and that mildly suppressive binocular/ multisensory cells and non-suppressive visual-vestibular neurons could be neural correlates of Bayesian-like computation in the brain. These nonlinear means could have Bayesian ends.

## #012 - Dissociable neuronal mechanism for different crossmodal correspondence effects

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Crossmodal correspondences (CMCs) refer to associations between seemingly arbitrary stimulus features in different sensory modalities. Pitch-size correspondences refer to the strong association of e.g. small objects with high pitches. Pitch-elevation associations refer to the strong association of e.g. visuospatial elevated objects with high pitches. We used functional magnetic resonance imaging (fMRI) to study the neuronal components, which underlie the CMCs in pitch-size and spatial pitch-elevation. This study focuses on answering the question of whether or not different CMCs are driven by similar neuronal mechanisms. The comparison of congruent against incongruent trials allows the estimation of CMC effects across different tasks. The analysis of the measured neuronal activity in both tasks strongly pointed towards different mechanisms which are involved in associations of pitch-size and pitch-elevation correspondences. Differential effects were observed within the angular gyrus (AnG) and the intraparietal sulcus (IPS). Further, the superior parietal lobule (SPL), cerebellum, Heschls' gyrus (HG) and anterior cingulate cortex (ACC) were engaged in processing both tasks but showed different effects for processing congruent compared to incongruent trials. In summary, the present results indicated clearly differential neural processing for different CMC tasks.

## #013 - Examining the Representation of Peripersonal Space in Adults with Fibromyalgia

Flavia Cardini 1, Jennifer Todd 1, Michael Lee 1, Jane Aspell 1

*1 : Anglia Ruskin University*

The space in the immediate vicinity of the body - termed Peripersonal Space (PPS; di Pellegrino et al., 1997) - is a crucial for the execution of actions towards reachable objects and for reacting to potential threats approaching the body (Graziano et al., 2006). Many studies have demonstrated the malleability of the PPS (Serino 2019). PPS increases in size in response to threatening stimuli, such as the approaching sound of a dog barking or the looming image of feared animals (Vagnoni et al., 2012). Given the protective role PPS plays, here we investigated the PPS in patients suffering from fibromyalgia, a long-term condition characterized by chronic widespread pain and fatigue (Sarzi-Puttini et al., 2020). We hypothesized that pain experiences in fibromyalgia might be associated with differences in the representation of PPS, with participants with fibromyalgia to exhibit a larger PPS, driven by the fear of threats from the environment. To test our hypothesis, we presented images of looming stimuli to participants with fibromyalgia (and to a control group of healthy participants) and we asked to make time to collision jugements (TTC). Results confirmed our hypothesis, showing larger PPS in participants with fibromyalgia compared to the age-matched, pain-free participants, evidenced by faster estimated TTC (i.e., stimuli were judged to collide with the body at a greater distance from the body). A larger PPS may reflect the sense of vulnerability in patients with fibromyalgia, driven by the fear of threats from the physical or social environment, and regular guarding against bodily pain.

## #014 - Effects of sound stimulus length and attributes on sound localization during self-motion perception

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During self-motion, the spatial relationship between objects and the observer changes from moment to moment. Nevertheless, people can properly localize the sound source position. This may imply that self-motion information can be used effectively to perceive stable sound space. Previous studies suggest that self-motion perception influences sound localization. For instance, the perceived position of a sound in the rear hemisphere was shifted rightward by a few degrees when an observer perceived self-motion to the right. However, a special sound stimulus, such as white or pink noise of duration less than 1 s, was used. The duration of the sound stimulus affects the stability of sound localization, and it is possible that the sound localization during self-motion varies with the length of the stimulus. Additionally, sound localization may be affected by the dynamic or static attributes of sound. Therefore, in this study, we investigated the effects of sound stimulus length and attributes during self-motion perception. Consequently, the precision of sound localization improved as the length of the sound stimulus increased. Furthermore, sound localization tends to shift opposite to the direction of self-motion. Based on the examination of the sound attributes as a parameter, the information of the sound movement is suggested to affect sound localization in the case of meaningful sounds.

## #015 - Multisensory interactions between nociception and vision through the looking glass

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It has been demonstrated that nociceptive stimuli influence the perception of visual stimuli especially when those visual stimuli occurred near the body, i.e. in the peripersonal space, a multisensory representation of the body integrating the external space immediately surrounding it. In the present study, we examined whether nociceptive stimuli influence the perception of visual stimuli when those are indirectly seen as occurring near the stimulated body parts. To this aim, we used a visual temporal order judgment task (TOJ) in which pairs of visual stimuli were presented, one to each side of space. Those visual stimuli were preceded by a nociceptive stimulus applied only on one of the hands to attract attention in one side of visual space. Visual stimuli were presented either at a far distance from the participants' hands or at a similar distance but indirectly seen near the hands through a mirror. It was expected that visual judgments would be biased to the advantage of the visual stimulus presented in the same side of space as the stimulated hand. Moreover, it was hypothesized that the visual bias induced by the nociceptive stimulus will be stronger in the mirror condition than in far condition, i.e. the condition without the mirror, even though stimuli are projected at a similar retinal distance in both conditions. Results showed that indeed, nociceptive stimuli facilitated more significantly the perception of visual stimuli in the mirror condition. Multisensory interaction between nociception and vision seems driven by a mental representation of the peripersonal space.

## #016 - The Impact of Premature Birth on Multisensory Processes in Very Preterm Schoolchildren

Marion Décaillet 1, 2, 3, Solange Denervaud 4, Laureline Besuchet 1, 2, Cléo Huguenin-Virchaux 1, 2, Céline Fischer 1, Micah Murray 2, 3, 5, Juliane Schneider 1, 2

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Interactions between stimuli from different sensory modalities and their integration are central to daily life. Being born prematurely and the NICU experience can have an impact not only on sensory processes, but also on the manner in which information from different senses is combined – i.e. multisensory processes. Very preterm (VPT) children(<32 weeks gestational age) present impaired multisensory processes in early childhood persisting at least through the age of five. However, it remains largely unknown whether and how theses consequences persist into later childhood. Here, we evaluated the integrity of auditory-visual multisensory processes in schoolchildren. VPT children (N=28; aged 8-10 years) received a standardized cognitive assessment and performed a simple detection task at their routine follow-up appointment. The simple detection task involved pressing a button as quickly as possible upon presentation of an auditory, visual, or simultaneous audio-visual stimulus. Compared to full-term children (N=23; aged 6-11 years), VPT children were generally slower, regardless of sensory modality. However, both groups showed a visual dominance over auditory. Likewise, both benefited from the multisensory presentation and exhibited similar percentages of multisensory gains on reaction times. By contrast, while gains in full-term children necessitated integrative processes, this was not the case for VPT children. Finally, no standardized cognitive or clinical measures predicted the multisensory gain in VPT children. These findings provide the first evidence that VPT children persist to show atypical multisensory profiles at school age. Therefore, it supports the aim of studying in-depth the underlying neural substrates of multisensory integration in VPT children.

## #017 - Increases in pre-stimulus theta oscillations precede successful encoding of crossmodal associations

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A central aspect of episodic memory is the formation of associations between stimuli from different modalities. Current theoretical approaches assume a functional role of different aspects of ongoing theta band oscillations for the encoding of crossmodal associations. In this study, we tested the hypothesis that pre-stimulus characteristics of theta band oscillatory activity are relevant for the successful formation of crossmodal memory. The experimental design that was used allowed for the isolation of the associative memory, independent from item memory. Participants (n = 51) were required to memorize associations between audiovisual stimulus pairs and distinguish them from newly arranged ones consisting of the same single stimuli in the subsequent recognition task. Our results show significant differences in the state of pre-stimulus theta oscillations between remembered and not remembered crossmodal associations, clearly relating increased power to successful recognition. These differences were positively correlated with memory performance, suggesting functional relevance for behavioral measures of associative memory. Further analysis revealed similar effects in the alpha and low beta frequency ranges, indicating the involvement of different pre-stimulus-related cognitive processes. In contrast, phase-based connectivity measures were not different between remembered and not remembered stimulus pairs. These results do not support the theoretically relevant role of phase-coupling as a basic function for the formation of crossmodal memory. The results from this study support the assumed functional relevance of theta band oscillations for the formation of associative memory and demonstrate that an increase of theta band oscillations in the pre-stimulus period is beneficial for the establishment of crossmodal memory.

## #018 - Memory formation of sequence-specific crossmodal associations is facilitated by dynamic changes in wide-spread alpha/beta power differences

Marike Christiane Maack 1, Jan Ostrowski 1, Michael Rose 1

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As our environment is highly complex, we are confronted with information from two or more modalities (crossmodal information). There is evidence that our cortical sensory system can process information from different sensory modalities and integrate them. However, it still needs to be clarified when and how our cortical system binds and retains crossmodal serial information during learning. In the present experiment, we combined electroencephalography (EEG) with a crossmodal sequential learning task to uncover the neural dynamics underlying the acquisition and recognition of crossmodal information. In this task, 32 healthy participants had to associate pairs of stimuli (visual, auditory) which were presented sequentially. Importantly, in half of the trials, the visual stimulus was presented before the auditory and vice versa. Afterwards, a recognition task was conducted to verify successful memory formation. Our behavioural data revealed that participants acquired stimulus pairs equally independent of the sequence they were presented in (visual-auditory, auditory-visual). Our neural data indicate neural processing differences between successfully remembered and forgotten trials based on their presentation sequence. Most strikingly, we observed a difference in alpha/beta power during the presentation of the second stimulus from each pair. Where visual-auditory pairs were processed with a lower alpha/beta power, we observed higher power differences in auditory-visual pairs. This effect most likely reflects a specific memory mechanism, as it was observed for the contrast of remembered against forgotten trials only. Our findings suggest an essential role of alpha/beta activity during the acquisition of crossmodal information and especially the sequence they are presented in.

## #019 - Zooming on the spectrum: exploring the relationship between autistic traits, sensory sensitivity and Zoom-fatigue

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Since the onset of the COVID-19 pandemic, video conferencing (VC) has become an integral part of our society. While VC is often a convenient alternative to meeting face-to-face, it may induce symptoms of mental and physical exhaustion, or: Zoom-fatigue. Compared to face-to-face meetings, VC requires increased cognitive and sensory demands, which may lead to sensory overload. The socio-communicative difficulties and alterations in sensory sensitivity associated with autism spectrum disorder (ASD) may pose as potential risk factors for Zoom-fatigue. The current study examined if individuals with high levels of autistic traits are more susceptible to Zoom fatigue. A large-scale online survey was conducted among older adolescents and young adults with typical development, and individuals in the same age range with ASD. Zoom fatigue was measured using the Zoom Exhaustion & Fatigue (ZEF) scale. Autistic traits were assessed with the Autism Spectrum Quotient (AQ), and sensory sensitivity was measured using the Glasgow Sensory Questionnaire (GSQ). Data collection is ongoing and will be completed by June 2023. Preliminary data from 225 participants showed that increased levels of autistic traits are associated with increased symptoms of Zoom fatigue, and that this relationship is partially mediated by sensory sensitivity. Results from the final sample will be presented at the conference, but these preliminary results suggest that individuals with increased autistic symptomatology may face unique challenges in the use of VC. These findings may help increase awareness of neurodiversity in computer-mediated communication, and may provide an impetus for the development of more accessible and inclusive VC solutions.

## #021 - Sniff or Not Sniff, That Is A Question for Egocentric Odor Localization

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Odors provide vital information (e.g., localization) to assess the environment for creatures by sniffing. While sniffing/respiration works as an essential procedure of odor perception, the effect of it on egocentric odor localization has not sufficiently assessed. Given that humans can only egocentrically localize the odors which activate the trigeminal nerve, here we investigated the potential effect of sniffing on the localization capacities of both pure olfactory stimulus (only activate the olfactory nerve, i.e., phenylethyl alcohol, PEA) and mixed olfactory/trigeminal stimulus (activate both the olfactory nerve and the trigeminal nerve, i.e., menthol). We asked participants to fulfill the odor localization tasks with three odors (PEA, menthol, and odorless propylene glycol) under two odor delivery methods (active sniffing or passive delivery). We found sniffing facilitates humans' egocentric localization of mixed olfactory/trigeminal stimulus while holding breath promotes localization of pure olfactory stimulus. Intriguingly, PEA was monorhinally localizable under the non-sniffing condition, which could be interpreted by that stimulus accumulation activates the trigeminal nerve in the nasal.

## #022 - Exploring the effect of ASMR on biomarkers and interpersonal space

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*1 : Anglia Ruskin University*

Autonomous Sensory Meridian Response (ASMR) describes a warm and pleasant experience of tingling sensations starting at the crown of the head and sometimes spreading down the body. This sensation is often evoked in response to various audio-visual triggers such as whispering, tapping and hand movements. This subjective experience has been often associated with feelings of calm and relaxation (Barratt and Davis, 2015). The benefits from experiencing ASMR are widely accepted, with people successfully relying on ASMR videos to help relieve stress, anxiety and insomnia. Yet, so far mostly anecdotal evidence supports these beneficial effects. Recent research findings have unveiled physiological (Poerio et al., 2018) and neuroimaging (Lochte et al., 2018) correlates of ASMR, showing activation of areas involved in empathy, social cognition and emotional arousal. The aim of the current study is twofold: 1) to unveil any hormonal correlates of the calming effect induced by ASMR and 2) to investigate if this calming effect promotes people's affiliative behaviours. Participants' saliva was collected, and their interpersonal space (IPS) measured, before and after watching a video inducing ASMR - or a control video. ASMR induced a significant reduction in IPS, suggesting an increased proneness to allow the others to come closer, after experiencing ASMR. However no changes in levels of Alpha Amylase –key hormonal indicator of a stress response – were found. Results suggest that ASMR can reliably promote and improve interpersonal connection, but this is not mediated by the calming experience induced by ASMR.

## #023 - Surprising new insights on the effects of multisensory distraction on developing working memory

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Real-world environments are full of distracting information that stimulates multiple senses at a time. Multisensory information is known to be highly salient, and multisensory distractors should be especially disruptive for children's cognitive processes, since they are assumed to be more distractible than adults. Understanding how working memory (WM) is affected by multisensory distractors is especially important, since school learning involves heavy usage of WM in multisensory-distractor-laden classroom settings. To this end, we measured the WM performance of 60 young adults (aged 18-35), 58 older children (aged 8-10) and 58 younger children (aged 6-8) on a visual change detection task with either: no distractors, visual distractors, auditory distractors or audiovisual distractors. Surprisingly, we found that visual, not multisensory, distractors were the most disruptive. Further, there was no evidence for differences in distractibility between the age groups. Thus, contrary to assumptions based on multisensory literature, multisensory information may not be especially disruptive to visual WM. Rather, in line with classic WM literature, distractors from the same (visual) domain as the to-be-remembered information are the most disruptive to WM performance. That said, whether the distractor is visual or multisensory, children's WM may be just as resistant to distraction as that of adults, holding promise for the robustness of their learning outcomes even in distractor-rich environments.

## #024 - Back to the past: the impact of illusory ownership of a child-like body on childhood memories

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Background – While experiencing and interacting with the immediate environment, there is an implicit sense of one's own body being owned by oneself - body ownership (BO; Ehrsson, 2012). However, it is not known whether aspects of the bodily self including BO impacts the recollection of events experienced in the past. In this study, we examine whether embodying a child's body via a full body illusion (FBI) facilitates the access to childhood memories. Methodology – Data was collected from 50 healthy adults. FBI was used to manipulate BO in participants with either a child-sized mannequin (n = 25) or an adult-sized mannequin (n = 25). For each participant, 90 seconds of synchronous visuo-tactile stimulation (the participant's body being touched at the same time and location as where they viewed the mannequin being touched in a video-based virtual reality setup) or asynchronous visuo-tactile stimulation was used to generate strong or weak BO for the mannequins. After each condition the strength of illusion was measured via questionnaire and the participants completed an autobiographical memory interview. Results – Participants experienced a greater BO for the mannequins following synchronous compared to asynchronous visuo-tactile stimulation ($p < .001$). We also found that the participants who viewed the child-sized mannequin were able to recollect more detailed episodic childhood memory of themselves compared to participants who viewed the adult-sized mannequin ($p = .004$). Conclusion – Our findings show that experiencing ownership of a child-like body facilitates greater recollection of childhood memories. This suggests that bodily self representations and autobiographical memory interact.

## #026 - Investigation of the effect of distractors on localization abilities with a visual-to-auditory substitution device

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Visual-to-auditory sensory substitution devices are assistive tools for the blind that convert visual images into soundscapes. These systems are meant to be used in daily life where it is common to evolve in complex scenes with various potential obstacles that have to be localized simultaneously. It is thus of a first importance to establish to what extend the function of the device (localization, navigation, recognition) can be accomplished depending on the complexity of the scene. So far, localization abilities with a substitution device have not been directly assessed in complex scenes with other irrelevant objects (or distractors). In this study, we evaluate the ability to perform a localization task in simple and complex spatial configurations where blindfolded participants had to localize a virtual target displayed alone or among virtual distractors, only relying on soundscapes. Results suggest that increasing the complexity can dramatically decrease the performances to a magnitude that can make such systems inoperable. These results stress out the importance of the accordance between the limits of the space in which obstacles are sonified and the complexity of the context in which the user evolves.

## #027 - Comparing the McGurk effect across Finnish and Japanese talkers and listeners

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In the McGurk effect, perception of spoken syllables is altered when an auditory (A) syllable is presented with discrepant visual (V) syllable (e.g. A/pa/V/ka/ is often heard as /ta/). Some research has suggested that when the talker is non-native, the McGurk effect is stronger (fewer responses according to A syllable). In contrast, other studies have not shown this non-native effect. Most studies have compared English with other languages. We investigated the non-native talker effect with Finnish and Japanese speakers. The participants included native speakers of Finnish (n=49, 35 females, mean age 22) and native speakers of Japanese (n=50, 30 females, mean age 21), none of whom knew the other language. The stimuli were /ka/, /pa/ and /ta/ uttered two female and two male native talkers in each language, with 5 samples of each syllable per talker. These stimuli were selected since they are native syllables in both languages. The stimuli were presented in A, V and audiovisual (AV) modality, including a McGurk stimulus A/pa/V/ka/. Participants responded /ka/, /pa/ or /ta/ according to what they heard in A and AV, and what they saw in V modality. The results showed a stronger McGurk effect with Japanese stimuli in both participant groups, contrary to a non-native effect. Differences in the McGurk effect were more prominently influenced by individual talkers. These results emphasize the need to investigate the stimulus features contributing to the McGurk effect, as well as to use a large set of talkers as stimuli in studies on AV speech perception.

## #028 - A novel system to evaluate audio-spatial memory skills: the Audio-Corsi

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Spatial memory (SM) allows a multimodal representation of the external world, which different sensory inputs can mediate. It is essential in accomplishing everyday activities and strongly correlates with sleep processes. However, despite valuable knowledge of the spatial mechanisms in the visual modality, the multi-sensory aspects of SM have yet to be thoroughly investigated due to a lack of proper technologies. This work presents a novel acoustic system built around 3D audio spatial technology. Our goal was to examine if an afternoon nap can improve memory performance, measured through the acoustic version of the Corsi Block Tapping Task (CBTT), named Audio-Corsi. We tested five adults over two days. During one of the two days (Wake), participants performed the Audio-Corsi before (Pre) and after (Post) a wake resting period; while the other day (Sleep), participants performed the Audio-Corsi before (Pre) and after (Post) a nap. Day orders were randomized. We calculated the memory span for the Pre and Post session in both the Wake and Sleep days. Preliminary results show a significant difference in the memory span between the Wake and Sleep days. Memory span decreased between the pre-and post-test during the wake day. The opposite trend was found for the sleep day, thus indicating that SM can be improved by sleeping also in the acoustic modality. The technology and procedure we developed could be suitable in clinical and experimental settings to study SM in the auditory sensory modality, spatial abilities and their relationship with sleep when vision is absent or distorted.

## #029 - The associative property holds for combination of auditory, visual, and tactile signals in multisensory decisions

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A prominent finding in multisensory research is that response times (RTs) are faster to bimodal signals compared to the unimodal components, which is the redundant signals effect (RSE). An intriguing explanation of the effect comes with race models, which assume that responses to bimodal signals are triggered by the faster of two parallel decision units, which can be implemented by a logic OR-gate. This basic model architecture results in statistical facilitation and the RSE can be predicted based on unisensory RT distributions and probability summation. To test the explanatory power of the framework, an expansion of the bimodal RSE is that RTs to trimodal signals are even faster. To measure the effect, I presented three unimodal signals (in vision, audition, and touch), all bimodal combinations, and a trimodal condition. To adapt the model, a corresponding extension simply assumes that responses are triggered by the fastest of three parallel decision units. Following the associative property in mathematics, an interesting proposition is that probability summation with any bimodal and missing unimodal RT distribution should equally predict the trimodal RT distribution. Furthermore, the expected RSE can in fact be computed for any combination of uni- and bimodal conditions, which results in a total of seven parameter-free predictions. Remarkably, the empirical effects follow these predictions overall very well. Hence, the associative property holds. Race models are consequently a strong and consistent candidate framework to explain the RSE and provide a powerful tool to investigate and understand perceptual decisions with multisensory signals.

## #030 - The effect of Audio-visual-haptic Training on Overtaking Learning Outcomes in a VR and Computer Environment

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Learning to drive in a simulated environment is not only safer, but provides the user with the ability to manipulate various sensory stimuli which cannot be easily replicated in reality. A Virtual Reality (VR) environment can provide the user with a safe environment from which they can both learn and be assessed in. Previous research conducted by the authors found that a combination of VR with the inclusion of additional task relevent multisensory cues (MSCs) was just as effective at teaching people to perform a sequence learning task than a physical environment. As the process of driving involves the recall of various driving based sequences, the present study investigates whether the inclusion of additional multisensory cues in a VR environment can improve driving based learning outcomes. Participants were instructed on how to perform a vehicle overtaking manoeuvre in either a VR with MSCs, VR without MSCs or a computer environment without MSCs. After training, they were tasked with navigating through a course which required the learner to regularly overtake vehicles. Learners' ability to correctly overtake was assessed by the number of times they collided with a vehicle (oncoming and stationary), closest distance from these vehicles, and how many times they checked their mirrors during the course. Preliminary findings are discussed.

## #031 - The developing homunculus: neuroplasticity in children with and without upper limb differences

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Congenital hand loss 'frees up' multiple brain resources normally dedicated to hand function. In adults, recent research shows that the territory of the missing hand in primary somatosensory cortex (S1) is activated by multiple body parts. It has been suggested that this remapping is facilitated by compensatory strategies – body parts which are being used to substitute the missing hand function will harness the freed-up hand resources, though this theory hasn't been empirically validated. A key question, therefore, is whether the brain remapping observed in adults is pre-determined from the onset of development, or whether these changes are dynamically informed by the changing needs of the developing child as she incorporates new motor solutions to her compensatory repertoire. We measured the sensory activity across various body parts from forehead to foot, using fMRI) and compensatory behaviours in one- and two-handed children (6-8 y/o) and one-handed adults. We predicted that compensatory use of multiple body parts in childhood, but not adulthood, will shape the sensory representation of the body in one-handers. Preliminary results showed somatosensory remapping of the residual arm representation in the deprived hand area. Further analysis involving representation similarity analysis will follow to elucidate on differences related to developmental period (children versus adult), limb difference (one or two hands), and links with compensatory behaviour. This approach will not only comprehensively identify the basic topography of the somatosensory homunculus – in itself rarely done in children – but also examine potential widespread impacts of limb loss upon the entire developinghomunculus.

## #032 - Memory-guided reaching movements toward haptically-encoded spatial locations

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In the visual domain, the precision of memory-guided reaching movements gradually decays as the delay between vision withdrawal and movement onset increases. Do memory traces of haptically-encoded spatial locations show similar decays? Here we asked participants (n = 30, 6254 trials) to perform memory-guided right-handed reach movements toward targets held with the left hand. In the delay block, the left hand wasremoved after 2 seconds, and a right-handed reach was performed after a variable delay of 2, 4, or 6 seconds. In the no-delay block, the left hand was on the target for the whole trial duration. Targets were positioned in front and to the left of the participants such that the limb posture of the left hand during encoding was either the same or different from the limb posture required for the right hand to reach the target (posture-dependent vs.posture-independent conditions). The introduction of the shortest delay caused a decrease in precision, indicating that online haptic inputs play a crucial role in guiding reaching movements. Similarly to vision-based memory-guided reaching, precision decreased with longer delays. A further reduction in precision was observed for the posture-independent condition with the longest delay. Thus, our results suggest that haptic spatial locations are stored in both posture-dependent and posture-independent forms. However, the haptic memory trace of a spatial location persists longer when the limb posture required to successfully reach the target is compatible with the posture of the limb during the encoding phase.

## #033 - Neural Correlates Underlying the Interaction and Integration of the Audiovisual Personal Identity and Audiovisual Speech

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We communicate emotions through various nonverbal cues, such as face, voice, and touch. Previous studies have investigated the prototypical expressions of basic emotions through face and voice, but not through touch. The prototypes of various positive emotions other than happiness have not yet been demonstrated across all channels of face, voice, and touch. Therefore, we examined whether the prototypes would facilitate the perception of various positive emotions through these channels. In a preliminary experiment, the encoder freely expressed 11 positive emotions (happiness, pride, awe, elation, interest, amusement, relief, triumph, love, gratitude, and sympathy) to the decoder using either of facial expression, nonverbal vocalization, or touch and the decoder judged the expressed emotion. We analyzed the facial, vocal, and tactile expressions used in the preliminary experiment and revealed the prototypical expressions used when the decoder had perceived each emotion. For example, the prototype of gratitude was raising the cheeks and pulling up the corners of the mouth (AU6 and 12) in facial expressions, a low-pitched and loud voice in vocalizations, and an overlapping action in touch. We then conducted a main experiment using almost the same paradigm as the preliminary experiment, except that the encoder expressed 11 positive emotions using the prototypical or the non-typical expressions as instructed by the experimenter. Results of the main experiment showed that the prototypical expressions convey target emotions more effectively than the non-typical expressions (Figure 1). Our findings suggested that the prototypes found in our study may enable systematic manipulation of expressing various positive emotions.

## #034 - Modelling Multisensory Causal Inference with Scikit-NeuroMSI

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Computational models of the neural processes by which a common cause is inferred from unisensory signals are essential for multisensory integration research. Nevertheless, current computational approaches are typically limited to a specific experimental paradigm (e.g. neuronal or behavioural) and have different levels of analysis (e.g. computation or implementation) and sophistication. Overall, two different types of models for causal inference have been proposed in the literature: Bayesian models and neural networks. What is missing is a systematic comparison between the behaviour of these models, and a better understanding about how to interpret the neural circuits models in terms of a possible implementation of Bayesian Causal Inference computation. An important step towards this is providing software for both types of models within the same framework, leading to comparable performance outputs. This is a core feature of our package Scikit-NeuroMSI, a Python framework for multisensory integration modelling. Here we show how Scikit-NeuroMSI can be used to easily generate unity reports in the spatial ventriloquist paradigm employing two different modelling approaches: Bayesian Causal Inference (Körding et al., 2007) and Multisensory Causal Inference Network (Cuppini et al., 2017). By doing so, we aim at contributing to the creation of a unified computational framework that narrows the gap between neural and behavioural multisensory responses.

## #035 - The prototypical expressions can facilitate the perception of various positive emotions through face, voice, and touch

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Effective face-to-face communication requires the brain to integrate hierarchical and multisensory social cues, such as personal identity and speech. While the neural bases for integrating specific audiovisual cues have been studied for a long time, the neural mechanisms underlying their interaction remain unclear. In this study, we investigated the neural correlates underlying the interaction of these audiovisual social cues through two experiments. In experiment 1, using a 2 (congruency of the audiovisual identity) ×2 (congruency of the audiovisual syllables) ×2 (report auditory syllable or visual syllable) design, we found decreased syllable discrimination accuracy in the audiovisual incongruent identity condition than audiovisual congruent identity condition when participants were required to report the visual syllable. In experiment 2, using a 2 (congruency of the identity) ×2 (congruency of the syllables) design, a passive perception task, and functional magnetic resonance imaging (fMRI), we found that the incongruent identity showed higher activation at the bilateral posterior superior temporal gyrus/sulcus (rpSTG/S) and right posterior middle temporal gyrus(rpMTG) than congruent identity; the incongruent speech showed higher activation at right cuneus and left ventral inferior occipital cortex than congruent speech. Furthermore, the regions of interest analysis revealed significant interaction of the audiovisual identity and speech at the rpSTG/S. Overall, our findings suggest that the processing of audiovisual social cues from different domains is associated with distinct brain networks and that these social cues interact at the rpSTG/S to enable efficient face-to-face communication.

## #036 - The facilitating effect of maternal odor on rapid face categorization in the infant brain declines over the first year

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Recent studies have shown that a non-visual cue, maternal odor, is able to facilitate rapid visual categorization of faces in the 4-month-old brain. Since the ability to visually categorize faces undergoes dramatic changes during the first year of life, we asked whether face categorization is still under the influence of maternal odor as this ability improves beyond the age of 4 months? To answer this question, we recorded scalp electroencephalograms (EEG) of 4 to 12-month-old infants (N=50) during a 6-Hz presentation of natural images (6 images/sec) depicting living and non-living objects. As done in previous studies, faces (differing in gender, expression and viewpoints) were inserted once per second in the stream of visual stimulation to objectively measure a face-selective response at 1 Hz in the EEG spectrum. In addition, to monitor the effect of odor facilitation on face categorization during development, maternal and baseline odors were presented alternatively during visual stimulation. We first measure that face-selective neural activity recorded over the occipito-temporal cortex increases and complexifies between 4 and 12 months. At the same time, the perceptual benefit of adding maternal odor fades gradually with age, suggesting that when face categorization becomes better achieved based on the sole visual input, intersensory interaction is less required. The present study suggests a developmental trade-off between vision and olfaction to achieve efficient perception in the infant brain.

## #037 - Audiovisual temporal recalibration modulates eye movement-related eardrum oscillations

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Eardrum oscillations are systematically affected by eye movements, a phenomenon called eye movement-related eardrum oscillations (EMREO). One unsolved question is whether EMREOs adapt to sensory experience. If this is the case, repeated exposure to temporally incongruent audiovisual stimuli should change the temporal profile of EMREO. To test this hypothesis, an experiment was conducted in healthy individuals (n=24) in which temporal recalibration in audiovisual perception was induced: a brief tone and a white light ring were presented in an adaptation phase, in one session synchronously (SOA = 0ms) and in another session with a temporal discrepancy (SOA = 230ms, visual lead). Eardrum oscillations and eye movements were recorded before and after the adaptation phases using in-ear microphones and an eye tracker, respectively, while participants were freely viewing images on a screen. In the post-adaptation phases, every one minute of free-viewing was preceded by 30 top-up stimuli in order to maintain the induced adaptation. Regression analysis of the eye movement and eardrum data aligned to saccade onsets revealed significant EMREOs before and after both 0 ms and 230 ms adaptation which were similar at a group-average level. However, adaptation with 0 ms SOA reduced the between-subject variation in the EMREO amplitude compared to baseline, while adaptation with 230 ms SOA increased the between-subject variation in the EMREO amplitude. These results indicate a dependency of the EMREO signal on the temporal processing of the audiovisual stimuli, suggesting that crossmodal recalibration can result in changes in the peripheral sensory transduction process.

## #038 - Characterizing the context-dependence of head pointing errors in virtual reality

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Head-pointing to acoustic or visual stimuli is inaccurate, insofar as the angle between head orientation and stimuli is overestimated, and the overestimation increase is directly proportional to the head eccentricity. Such error pattern recalls the “central tendency bias” effect, the estimation bias toward the mean of the stimuli distribution, that is, of the perceptual context. Nevertheless, to date the head-pointing errors have been reconducted to biases in low-level perception per-se or to the imperfect combination of spatial cues coming from different coordinates (retino-centric, head-centric, body-centric, and so on…), while the perceptual context has been overlooked. Here, we tested for the presence of a “central tendency bias” in head-pointing errors in the typical population by comparing the error distributions obtained in a head-pointing task performed in virtual reality, using virtual visual or acoustic stimuli placed between -30° and +30° from the head starting position, which in turn could be at 0°, +45°, and -45°. The resulting error distributions confirmed the presence of a “central tendency bias” effect, which was stronger when the head was turned rightwards and seemed perceptual modality-irrelevant. Such spatial asymmetry, which recalls the pseudoneglect phenomenon, and the modality-irrelevance of the effect, suggest that the bias arises at a high level of the spatial information encoding process. Overall, the results found suggest the head-pointing overestimation may underlie the expectation that items in space will be placed on average frontally. These findings extend the knowledge about the mechanisms underlying the perceptual biases, arguing in favor of the “Bayesian brain” hypothesis.

## #039 - Neural speech tracking benefit of lip movements predicts behavioral deterioration when the speaker's mouth is occluded

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Observing lip movements of a speaker is known to facilitate speech understanding, especially when speech is challenging. Neuroscientific studies showed that this visual benefit is also represented in the brain. However, the interindividual variability of this benefit and its consequences on behavior are unknown. Here, we analyzed source-localized magnetoencephalographic (MEG) responses from normal hearing participants listening to audiovisual speech with or without an additional distractor speaker. Using temporal response functions (TRFs), we show that neural responses to lip movements are in general enhanced when speech is challenging. After conducting a crucial control for speech acoustics, we show that lip movements effectively contribute to higher neural tracking, particularly in challenging speech. However, the extent of this visual benefit varied greatly among participants. Probing the behavioral relevance, we show individuals who benefit more from lip movement information in terms of neural speech tracking, show a stronger drop in performance and an increase in perceived difficulty when the mouth is occluded by a surgical face mask. In contrast, no effect was found when the mouth was not occluded. We provide novel insights on how the benefit of lip movements in terms of neural speech tracking varies among individuals. Furthermore, we reveal its behavioral relevance by demonstrating negative consequences on behavior when visual speech is absent. Our results also offer potential implications for future objective assessments of audiovisual speech perception.

## #040 - Effects of Crossmodal Association Learning on the Processing of Audiovisual Spatial Information: An EEG Study

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Deciding when to integrate or segregate information from different sensory systems is a challenging task. Causal inference models and experimental studies have shown that the probability of two stimuli having a common cause is partly inferred from acquired prior knowledge about stimulus occurrence. Such priors reflect top-down influences which have been linked to oscillatory alpha- and beta-band activity. However, the neural basis of top-down control in multisensory spatial processing is yet not fully understood. Here we tested the influence of crossmodal associations on neural processes underlying audiovisual spatial integration. In an association phase, we presented participants two different spatiotemporally congruent audiovisual stimulus pairs (i.e., sound frequency-color combinations). In a following test phase, one of the two tones (or a previously unpaired new tone) was flanked by the two previously seen visual stimuli. Participants were asked to localize the tone, and the perceived shift from the actual auditory location towards the previously associated visual stimulus was assessed as a behavioral measure of top-down effects on audio-visual spatial binding. Moreover, EEG was continuously recorded. We hypothesized that an auditory localization shift (the ventriloquist effect) towards the associated visual stimulus (i.e., the stimulus with the higher probability of a common cause) is associated with an enhanced contralateral N260. Furthermore, we expected the top-down influence on multisensory spatial integration to be reflected in lower alpha-band activity contralateral to the associated visual stimulus.

## #041 - Psychophysical investigation of localization of audio-tactile stimuli in active touch

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Exploring our environment through touch often entails integration of tactile cues with auditory and/or visual inputs. The mechanisms by which touch integrates with other sensory modalities in conditions of active touch remain poorly understood. Here, our aim was to investigate auditory-tactile integration in the context of spatial localization of transient changes in friction. Using psychophysics, we investigated the precision of participants localizing tactile, auditory, and audio-tactile stimuli relative to a visually-displayed midline, in active touch. In Experiment 1, conditions were presented in separate blocks, and participants were informed about modality prior to each block. In Experiment 2, conditions were fully interleaved, and participants did not receive information about modality prior to each trial. For both experiments, we estimated within-subject differences across conditions, and assessed whether bimodal stimulus presentation improves localization precision (slope of the psychometric function). In both experiments, similar slope values were observed for the tactile-only and the audio-tactile conditions, both displaying higher precision compared to the auditory-only condition. However, we observed a reduction in bias (greater accuracy) in the bimodal condition when participants could not predict modality. Our results suggest that participants relied more on tactile stimuli to perform the task, thus precision was not improved by concurrent auditory stimulation. While it is possible that participants largely ignored auditory cues in the bimodal condition when information about modality was given, when modality was not predictable, integration of auditory and tactile stimuli led to a more accurate spatial haptic representation, albeit without a significant reduction in uncertainty.

## #042 - Exploring whether hMT+/V5 represents spatial frequencies when processing moving visual and auditory information.

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The hMT+ region of the brain has been established as being highly responsive to motion perception, particularly also in relation to specific features such as the spatial frequencies of visual stimuli. Moreover, recent studies have revealed that hMT+ is not solely involved in motion processing within the visual modality, but also exhibits activation in response to stimuli presented in the auditory modality. However, it remains unclear whether hMT+ demonstrates selectivity for spatial frequencies in this alternative sensory modality. To address this question, we conducted a functional magnetic resonance imaging (fMRI) experiment at an ultra-high magnetic field strength (7T), involving a cohort of 15 participants. During these sessions, participants were presented with visual and auditory stimuli, each involving translational motion, and were exposed to two distinct spatial frequencies (low and high). We use Multivariate Pattern Analyses (MVPA) allowing us to discern potential differences in hMT+ activation patterns between the two spatial frequency conditions across modalities. Preliminary findings from the visual domain indicate that hMT+ indeed exhibits divergent activation patterns in response to the two spatial frequencies. We are currently exploring whether similar results would be observed in hMT+ when participants process auditory motion. Additionally, we aim to ascertain whether the spatial frequency pattern information is shared across the sensory modalities using cross-modal MVPA analyses.

## #043 - Landmark distortions of target localizations within and across modalities

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Landmarks have shown to produce spatial distortions of target localizations. Shifted target localizations both in landmark direction, so called landmark attraction, as well as against landmark direction, so called landmark repulsion, have been reported in the literature. Different influencing factors like attentional influences or landmark stability have been discussed as influencing factors whether landmark attraction or landmark repulsion occurs. Crucially, both patterns of spatial distortions have been observed when landmark and target where both presented in the visual or the tactile modality, yet never across modalities. In two experiments (each N = 24) both target and landmark were either presented in the tactile modality as vibrotactile stimuli on the left forearm or in the visual modality as white circles on a touch monitor attached to the left forearm. Consequently, target and landmark were presented either in the same or different modalities. Additionally, uncertainty of the visual targets was varied across experiments, as a possible influencing factor whether landmark attraction or landmark repulsion occurs. Tactile targets showed an overall pattern of landmark attraction, independent of landmark modality. Visual targets also showed comparable patterns of spatial distortions regardless of the landmark modality, yet a pattern of landmark attraction only occurred when visual uncertainty was low. When visual uncertainty was high, a pattern of landmark repulsion occurred instead. In summary, visual and tactile landmarks influenced target localizations in comparable ways both within and across modalities. Further, visual uncertainty seems to influence whether a pattern of landmark attraction or landmark repulsion occurs.

## #044 - Psychological relativity in tactile motion perception

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This work focuses on how space-time dependencies can alter the perception of a moving object. This phenomenon highlights the role of motors schemes in movement perception and reveals an apparent motion attribution mechanism, which predicts the future position of the moving object. In this study, we investigate whether this mechanism is present in the tactile modality and, if applicable, how the implementation of this mechanism is determined by the informational ambiguity of the stimulation. To answer this question, we rely on the "two-third power law" which is identified in the motor and visual domains and reveals a relationship between the radius of curvature and the tangential velocity of motion. The experiment consists of stimulating the surface of the participants' right-hand palm in four different configurations of tactile patterns, two congruent and two incongruent. The congruent stimuli have a circular shape with a constant tangential velocity of displacement and an elliptical shape with a variable tangential velocity of displacement following the "two-third power law". Incongruent stimuli switch the temporal patterns of these spatial trajectories. Participants were then asked to discriminate whether they perceived a circle or an ellipse and to associate a confidence level with their response. The results show a significant effect of incongruence on discrimination performance, with 76% performance for congruent stimuli and 38% for incongruent stimuli. Stimulus incongruence also impacts participants' confidence level, which decreases when stimuli are spatiotemporally incongruent. The confidence level data were further analyzed with a metacognitive measure. In the incongruent case, the responses provided are characterized by a higher level of uncertainty. In conclusion, the results suggest that the apparent motion attribution mechanism is present in the tactile modality and can also distort perceptual reality in this modality. This may have important implications for the design of tactile interfaces and for the understanding of multisensory motion perception.

## #045 - Distinct profiles of multisensory processing between professional goalkeepers and outfield football players

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In association football (soccer), the position of goalkeeper is the most specialised position in the sport and has the primary objective of stopping the opposing team from scoring. While previous studies have highlighted differences in physiological and match performance profiles between goalkeepers and outfield players, surprisingly little research has focused on whether goalkeepers differ in terms of their perceptual-cognitive abilities. Given that goalkeepers use multiple sensory cues and are often required to make rapid decisions based on incomplete multisensory information to fulfil their role (Franks & Harvey, 1997), we hypothesised that professional goalkeepers would display enhanced multisensory temporal processing relative to their outfield counterparts. To test this hypothesis, we measured the temporal binding windows of professional goalkeepers, professional outfield players and a control group with no professional football experience using the sound-induced flash illusion (Shams et al., 2000). Our results revealed a marked difference in multisensory processing between the three groups. Specifically, we find that the goalkeepers displayed a narrower temporal binding window relative to both outfielders and control participants indicating more precise audiovisual timing estimation. However, this enhanced multisensory temporal processing was accompanied by a general reduction in crossmodal interactions relative to the other two groups that could be attributed to an a priori tendency to segregate sensory signals. We propose that these differences stem from the idiosyncratic nature of the goalkeeping position that puts a premium on the ability of goalkeepers to make quick decisions, often based on partial or incomplete sensory information.

## #046 - Reaching and Grasping time in infants: the effect of an early visual impairment

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Learning to reach for and grasp an object with either one or both hands is an important milestone in infants that include a series of actions such as transporting the arm, pre-shaping, opening, and closing the hand. Vision plays a pivotal role in the maturation of these skills, which is delayed in the case of early visual impairment. This study compares the time of reaching and grasping execution between sighted and visually impaired infants aged between 0 and 3 y/o. Participants were video-recorded during a reaching task for three black spheres with 3, 5, and 8 cm of diameter, located on a black table at three positions (i.e., central, right, and left) in a dimly light room. On each trial, the experimenter gently slammed the sphere in one of the three positions, and the child was instructed to reach and grasp for it by following the sound produced by the slamming and to give it back to the experimenter. We found that visually impaired participants need more time to reach and grasp an object than sighted infants. Furthermore, sighted infants use less time to grasp than reach the sphere. The results highlight the importance of visual experience in programming fast and accurate goal-directed movements and create the basis for developing rehabilitation procedures to foster the maturation of these skills in blind infants.

## #047 - Perceiving more than expected: the deviation of responses to bimodal stimuli from race model prediction

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Introduction. Smaller Reaction Times (RTs) to bimodal versus unimodal stimuli in detection tasks (known as Redundant Signal Effect, RSE) are critical to understanding how the attentional system works. According to the race model, RSE is obtained when the response to redundant stimuli is given as soon as the first stimulus is detected. Multisensory integration happens when responses to bimodal stimuli are faster than the model's predictions. In the present study, we tested the modulation of the cognitive load in the bimodal integration: we expected a deviation from the model's prediction in the earliest RTs for the low cognitive load. Participants and Methods. We measured the RTs of 28 sighted adults on a spatial attention task comprising different cognitive loads (high or low) and different sensory stimulations (unimodal and bimodal) delivered with a newly developed technological device. Results. We compared the RTs distribution of the subjects with the prediction of the race model. Results showed a violation of the model modulated by the cognitive task: this effect is greater for the low cognitive load than the high one. Furthermore, this specific task modulation especially regarded the subjects' earliest RTs. Conclusion. The present work is consistent with the idea that the race model predicts more low-level sensory aspects. The earliest RTs are more dependent on bottom-up processes, i.e., more perceptual, than top-down processes, i.e., more cognitive.

## #048 - Dynamic spatial representation for navigation activates the premotor cortex in blind subjects: virtual tools can reshape the peripersonal space

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Introduction: Space is not an unitary dimension; several studies show that the brain creates different representations of space that are processed by different brain regions. Distance from an object splits the space in peripersonal (PPS) versus extrapersonal space. Interesting, brain areas encoding the PPS are very plastic and can be trained to process the extrapersonal space as PPS. However, few is known about the dynamic online representation of PPS. This is an intriguing question as we use to update PPS representation while moving in the space. In this experiment, we tested in the fmri if a virtual auditory tool for navigation can activate and reshape PPS boundaries in sighted and in congenitally blind people. Method: We performed a fMRI experiment in which congenitally blind (CB) and sighted participants navigated the same 2 mazes. The sighted performed the mazes via vision, while the CB via audition. The CB performed the mazes before and after a training session using the EyeCane, a sensory substitution device (SSD) that provide dynamic information about distance between the subject and objects. Results: Sighted subjects show strong activation of the premotor cortex. Similarly, after the training, blind subjects activated premotor areas. Premotor cortex is a very plastic area that process PPS. Its function can be modulated by a training with a tool that enables the remapping of the far space. Our results suggest that blind people can create a dynamic spatial representation of PPS by using a virtual tool.

## #049 - Sighted people overestimate the experience with and ability of blind people in tactile face recognition

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A number of studies have investigated face-specific neural responses in the ventral “visual” cortices of people born blind using face touching tasks. However, little is known about how well blind people are able to recognize faces by touch or even the degree to which they do this in everyday life. One previous behavioral study found that a congenitally blind group was in fact worse at discriminating different face identities using touch than sighted and late blind groups. The current study used self-report meta-cognitive measures to investigate how likely congenitally blind adults would be to identify others through face touching and how well they believed they could do this. We also measured sighted people’s perceptions of blind individuals’ experience and ability in tactile face recognition. In two different cohorts (blind group 1, n= 18; blind group 2, n = 24; sighted group 1; n=18, sighted group 2, n=22), results demonstrate that sighted people significantly overestimate how likely blind people are to identify another person by face touching. The sighted groups also overestimated blind people’s ability for tactile face discrimination compared to responses from the blind participants. Results demonstrate that blind people have less experience and expertise with face touching than sighted people believe, suggesting tactile face perception is not an ecologically valid task for measuring face perception in blind individuals.

## #050 - Dissociation between dreams and wakefulness: Insights from body and action representations of rare individuals with acquired and congenital somatosensory deficits

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The realism of body and actions in dreams is thought to be induced by simulations based on internal representations used during wakefulness. As somatosensory signals contribute to the updating of body and action representations, these are impaired when somatosensory signals are lacking. Surprisingly, we recently showed that three individuals (GL, IW, and WL) who have suffered as adults from a severe sensory neuropathy for at least 20 years, can dream of themselves without their impairments. Despite their somatosensory loss and their altered control of daily movements, they could dream of themselves as able-bodied, with some sensations (touch, proprioception) and actions (such as running or jumping) which had not been experienced in physical life since the neuropathy onset (Chauhan et al., 2022). This is in accordance with findings on individuals with blindness, amputation or paraplegia who all tend to dream without their impairments. We speculated that simulation in dreams of somatosensory-deficient individuals could be based on former, “healthy” body and action representations. To test this former-representation hypothesis, we investigated the dream content of five individuals with congenital somatosensory deficits. Though they reported dreaming of body and actions most frequently similar to their waking life, unlike the previous participants with acquired neuropathy, they all reported that at least some actions in dreams were easier to perform than the same actions in waking life. Thus, our findings are consistent with the idea that, at least sometimes, distinct body and action representations may be used during dreams and wakefulness.

## #186 - Blindness does not hamper extension of touch localization on tools

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Tactile events frequently occur outside the body and on external objects. For example, tools can be used to extend tactile perception beyond the body—a classic example being when blind individuals use canes to pick up information about their surroundings. We recently found that sighted participants can accurately localize where an object touches a hand-held tool when they actively make contact with it. However, localization performance drops when tool-object contact is passive, suggesting that certain factors such as motor variables or tactile feedback play a role in forming the spatial percept. Despite being a paradigmatic case to address the debate about touch superiority in the blind, it remains unknown whether blind individuals surpass sighted individuals in tool-sensing abilities. To fill this gap, we compared sighted and blind participants on their ability to localize touch on the surface of a held-hand tool in both active and passive sensing conditions. To do so, we developed a novel paradigm that allowed participants to haptically report where an object made contact with the tool. Consistent with our prior findings, localization was more accurate and precise during active sensing compared to passive sensing. Remarkably, we found no difference in performance between the sighted and blind participants in either condition, supporting the arguments against touch superiority in the blind.

# POSTER SESSION #2
# JUNE 28 | 12-2 PM

## #051 - How do people navigate around physical vs. visual-only augmented obstacles?

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In our everyday life we interact with objects in our surroundings. We perceive these objects, through different senses, and then know how to plan our routes towards or around them. But what happens when the objects are virtual - i.e., added to our environment via augmented reality tools - and can be perceived only visually? Do users treat these visual objects like physical objects? Within this broad question, here we specifically focus on obstacles, and ask if users' spatial behavior is affected by their physicality? To test this, we developed a pass-through based augmented reality system that requires participants to walk back and forth in a hallway with real and virtual obstacles partially blocking their path, with their movements recorded. Our main measures are the effects of obstacles' physicality on movement patterns - how close did participants get to them? We will present the results of a feasibility test of this system, demonstrating that users can perform such tasks intuitively and easily. Additionally, our preliminary results indicate that while on the group level the difference between avoiding visual and physical obstacles are not statistically different, on the single participant level we see clear individual biases around virtual obstacles. Our system offers an intuitive setup for testing multisensory interaction with targets that are visual only vs. physically present. It has great potential both for the basic science of multisensory interaction, and practical potential both for rehabilitation and for the design of mixed reality interfaces.

## #052 - The influence of social interactions on visuotactile causal and perceptual inference

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When interacting with the environment humans need to integrate information coming from different senses. This is particularly relevant when coordinating with other individuals of which we need to predict the movements. If and how interpersonal interactions differently modulate cross-modal interpersonal sensory integration processes, e.g., intersensory segregation and integration, both at the behavioural and at the neural level, remains an open question and appears to be relevant to understand the mechanisms that contribute to establishing a shared sensorial space between individuals. To study the impact of interpersonal coordination over interpersonal visuotactile integration mechanisms, we asked participants to engage in three different behavioural tasks implying different degrees of interpersonal interactivity and interpersonal visuotactile synchrony. After the tasks, we asked participants to report the number of flashes they perceived near the hand of their partner while concurrently receiving tactile stimulations over their hands. We manipulated the numerical disparity of visual and tactile stimuli presented during the same time-window in order to investigate multisensory integration/segregation processes and quantified the confounding effect of the tactile stimulation on the participants' visual percepts obtaining a visuotactile weight index. Furthermore, we measured EEG responses to index how the neural dynamics of intersensory segregation/integration were affected by the level of interactivity of the motor task. We aim at analysing the EEG (evoked and oscillatory) activity during pre- and post- stimulus intervals. We introduce a novel interpersonal multisensory integration task and we show that it is suitable for studying visuotactile interference effects. This provides new opportunities for theThis provides new opportunities for the study of multisensory sensorimotor processes and their modulation by

## #053 - Tilting the body affects perceived haptic length

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Correctly perceiving object size is necessary for successful interactions with the environment, like grasping a cup or navigating through a store. Both vision and the vestibular system affect size perception. Harris & Mander (2014) and Kim et al. (2022) found that participants perceive the length of a visually presented rod as smaller (need to set it longer by 5.4%-11%) than a physical rod in their hands when lying supine compared to when upright. But could the length of the physical rod also be misperceived? In the current study, we examined if changing the vestibular signal by lying a person supine might lead to changes in perceived haptic length. Blindfolded participants felt the length of one of three reference rods (40, 46 or 52 cm long) while standing or supine. They then either maintained their posture or changed to the other posture and adjusted the length of a telescopic rod to match the previously felt length. Preliminary results show an effect of body posture on the perceived haptic length of the rod. Participants set the rod too long when they felt it while supine and adjusted while standing and too small when they felt it standing and adjusted while supine. Our results are consistent with participants perceiving the rod as approximately 4-5% longer when supine compared to when standing. This suggests that at least some of the previous findings attributed to changes in visual size or distance perception while supine can be attributed to changes in perceived haptic size.

## #054 - Mirror invariance for objects and Braille letters in congenitally blind people; an fMRI study

Maksymilian Korczyk 1, Katarzyna Rączy 1, Marcin Szwed 1

*1 : Jagiellonian University*

Mirror-images of objects are recognized as the same object, but letters aren't (“d” is not “b”). Studies show that the fusiform cortex is important in mirror discrimination in the sighted for words and letters. Moreover, the congenitally blind can easily recognize the orientation and shape of Braille letters, geometric figures, and familiar objects like the sighted. Here, we investigated which neural mechanisms underlie this process. Nineteen congenitally blind adults participated in our fMRI experiments. Stimuli were pairs of Braille letters, and everyday objects (e.g., toothbrush). All stimuli were presented in priming paradigm in three conditions: same (“p” and “p”), mirror orientation (“p” and “q”), and different (“p” and “z”). fMRI results showed mirror priming for everyday objects in the bilateral visual cortex. Additionally, we observed mirror discrimination for Braille letters in the left calcarine cortex and left lingual gyrus. However, in the fusiform cortex we did not observe mirror discrimination for Braille letters. Our results demonstrate a lack of obvious hierarchical processing in the visual cortex in the blind. As opposed to the sighted, Braille letters and object priming in the congenitally blind seem to activate a broad area of the visual cortex.

## #055 - Feedback processing shapes the categorical organization of the ventral stream

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The ventral stream shows a categorical organization that is driven by the feedforward processing of category-specific visual features. However, a partly similar categorical organization exists in the absence of visual input, suggesting that it is also shaped by topdown feedback processing. Here, to reveal such feedback processing, we focus on the selective response to large objects (buildings) in the scene-selective parahippocampal place area (PPA). We tested whether the selective PPA response to buildings: 1) is observed when controlling for visual features typical of buildings (e.g., rectilinearity), 2) is delayed relative to the PPA response to scenes, and 3) reflects top-down activation of scene representations. In an fMRI study with high temporal resolution (TR=140 ms), participants viewed images of buildings, visually matched boxes, scenes, and chairs. Results showed a selective PPA response to buildings (vs boxes), despite closely matching visual features. BOLD peak latency analyses showed that building-selective PPA responses peaked 200 ms later than scene-selective PPA responses, consistent with the hypothesized top-down activation of scene representations. This delayed PPA response to buildings was corroborated by an EEG study: decoding analyses revealed that building-selective responses emerged 350 ms after stimulus onset, about 200 ms later than scene-selective responses. Finally, building-selective response patterns at 350 ms after stimulus onset generalized to scene-selective response patterns at 200 ms after stimulus onset. Taken together, these results provide information about the nature of large-object selectivity in the PPA and, more generally, indicate that (some) categoryselective responses in visual cortex reflect top-down feedback.

## #056 - Crossmodal temporal functions are unaffected by transient periods of blindness or deafness

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The perceived onset of visual stimuli is usually shifted toward slightly asynchronous auditory or tactile stimuli, known as temporal ventriloquism. To test the dependence of crossmodal temporal functions on early sensory experience, we assessed the effects of transient periods of blindness or deafness on the temporal ventriloquism effect in later life. Our sample included sight restoration individuals who were born blind due to dense bilateral congenital cataracts or who were treated for developmental cataracts, as well as cochlear implant (CI) recipients who were either congenitally deaf, went deaf before 3 years of age (prelingual deafness), or after age 13 years (postlingual deafness). For each patient group, an age-matched control group was recruited. All participants judged the temporal order of two visual stimuli, presented in rapid succession above and below central fixation. In a subset of trials, additional task-irrelevant auditory or tactile stimuli accompanied the visual stimulation either synchronously or asynchronously, that is, leading the first and lagging the second visual stimulus by 100 ms. Unisensory visual performance was lower in cataract-reversal individuals than in controls but was indistinguishable between CI recipients and their controls. Compared to unimodal baseline, performance was only marginally affected by synchronous auditory and tactile stimuli. Importantly, all groups showed a significant and indistinguishable temporal ventriloquism effect, that is, an enhanced performance in the asynchronous crossmodal conditions. Thus, crossmodal temporal binding was unaffected by transient visual or auditory deprivation, suggesting that neither altered sensory experience during early phases nor during late phases of development caused permanent changes.

## #057 - Semantic meaning guides audiovisual attention in a continuous manner

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Semantic information influences attention in visual scenes, even when not relevant to an observer's current task. However, the role of semantic influence in multisensory contexts is less well understood. Recent studies showed that a task-irrelevant sound improves search performance for a matched visual target (hearing a bark speeds up search for an image of a dog compared to an unrelated sound). However, it is unclear whether this audiovisual search benefit extends to more distant semantic relationships, such as that between two instruments. To elucidate the role of semantic information in guiding audiovisual attention, we examined whether semantic relatedness modulates search speeds. Participants (n=109) searched for images while a sound played in the background. Search efficiency scales with semantic relatedness (r=-0.14, p=0.009), such that target images were found more quickly when presented simultaneously with a more semantically related sound. This result suggests that semantic meaning has a continuous influence on audiovisual attention and that the underlying mechanism is shared across visual and audiovisual attention. In a set of follow up experiments, we probe whether this audiovisual semantic benefit depends on the relevance of the image's semantic identity. When a target image's identity is not relevant to the response and the stimulus category is highly constrained and familiar, participants (n=181) found target images more slowly when the sound was more semantically related (r=0.22; p=0.02). The size of this audiovisual semantic distraction effect does scale with semantic relatedness, suggesting that crossmodal semantic information is rapidly available to modulate attentional prioritization.

## #058 - Allocentric reference frames are robust to changes in body tilt, but egocentric reference frames are not

Jong-Jin Kim 1, Pierre-Pascal Forster 2, Meaghan Mcmanus 2, Katja Fiehler 2, Laurence Harris 1

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People use both allocentric (re: space) and egocentric (re: self) reference frames when making judgements about landmark locations. Here we used a rotatable room to separate these frames and assess their relative contributions to the perception of body and landmark orientation. Participants (n=32) sat in York University's Tumbling Room in which the chair and room can rotate independently around the roll axis. For half the participants, the angle between the chair and the room was fixed at -45° counter-clockwise and the ensemble was rotated in total darkness by 0°, +22.5°, +45° and +67.5° clockwise, except for a baseline condition with them both upright. For the other half participants, the ensemble was mirrored. After viewing the room for 5 secs, participants were plunged into darkness again and aligned a luminous rod with either their memory of the room ("perpendicular to the ceiling"; allocentric task) or with their body ("parallel to your torso"; egocentric task). Alignment errors depended on the task and the tilt of the chair/room ensemble. Body tilt was overestimated by an amount that increased with tilt, but participants always pointed accurately to their memory of the ceiling. Such results suggest that people can use allocentric cues accurately over a large range regardless of body or room orientation around the roll axis. Judging body tilt depends solely on the body orientation and is not influenced by the room. We conclude that people can separate allocentric and egocentric cues and thereby focus on the task-relevant reference frame.

## #059 - Perception of the McGurk Effect in people with one eye depends on whether the eye is removed during infancy or adulthood

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The visual system is not fully mature at birth and continues to develop throughout infancy until it reaches adult levels through late childhood and adolescence. Disruption of vision during this postnatal period and prior to visual maturation results in deficits of visual processing and in turn may affect the development of complementary senses. Studying people who have had one eye surgically removed during early postnatal development is a useful model for understanding timelines of sensory development and the role of binocularity in visual system maturation. Adaptive auditory and audiovisual plasticity following the loss of one eye early in life has been observed for both low-and high-level visual stimuli. Notably, people who have had one eye removed early in life perceive the McGurk effect much less than binocular controls. The current study investigates whether multisensory compensatory mechanisms are also present in people who had one eye removed late in life, after postnatal visual system maturation, by measuring whether they perceive the McGurk effect compared to binocular controls and people who have had one eye removed early in life. People who had one eye removed late in life perceived the McGurk effect similar to binocular viewing controls, unlike those who had one eye removed early in life. This suggests differences in multisensory compensatory mechanisms based on age at surgical eye removal. These results indicate that cross-modal adaptations for the loss of binocularity may be dependent on plasticity levels during cortical development.

## #060 - An EEG Investigation of Multisensory Integration in ADHD Adults

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Increasing evidence suggests that sensory processing may be impacted in attentiondeficit/hyperactivity disorder (ADHD), but behavioural findings on whether multisensory integration is affected in ADHD are mixed. However, multiple imaging studies have now shown that even when little to no behavioural differences in multisensory integration are observed, differences in the neural mechanisms underlying integration are still seen. In this study, we examined whether multisensory integration is affected in adults with ADHD (n= 23; 23.8 years) compared to Neurotypical adults (n= 21; 18.7 years) using two speeded response tasks paired with electroencephalography (EEG) measures. Participants were presented with auditory pure tones, visual Gabor patches, or a combination thereof, all embedded in audiovisual white noise. Participants responded as quickly as possible when they detected any stimulus. Participants completed two versions of the task - one with stimuli presented at the participants' unisensory detection threshold, determined via a psychophysical staircase procedure (perceptually matched), and a second, stimulus-matched detection task. No group differences in accuracy gain were found in either task. There was no difference in the magnitude or number of violations of Miller's race model between the groups. However, preliminary analysis suggests there are neural differences in parietal and occipital regions between the two groups. Taken together, these results suggest that neural differences for multisensory integration may exist in individuals with ADHD compared to neurotypical adults, despite a lack of behavioural differences.

## #061 - How does simulated eye height affect size perception in different postures?

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Eye height influences visual object size (e.g., Leyrer et al., 2011). But in virtual reality, there are two simultaneous, independent eye heights: the simulated eye height above the ground plane and the external eye height above the physical ground. Can they both have an effect? Using virtual reality, participants (n = 40) compared the size of a red rectangle simulated at three different distances (6, 12, and 18 m) against the length of a physical stick held in their hands with all combinations of three physical eye heights in the real world (sitting ~125cm, standing ~165cm, and standing elevated on a table ~215cm) and three simulated eye heights that corresponded to each participant's real-world eye-heights (~125cm, ~165cm, and ~215cm). Simulated eye height correlated with perceived size. Physical eye height above the ground also affected perceived size: size was overestimated when standing on the floor relative to sitting and relative to standing on the table. There was an interaction between simulated and physical eye heights: people were more influenced by changes in simulated eye height depending on their external eye height. We have demonstrated for the first time an interaction between what happens inside virtual reality and people's knowledge of their physical position in the real world. This becomes a significant factor when VR is used for perceptual experiments where the simulated environment may be independent of the external ground plane.

## #062 - How the characteristics of a virtual environment affect the perception of moving through it

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Although virtual reality has been widely used to investigate the perception of travel distance, the characteristics of these virtual environments vary greatly between studies. Previous research from our lab (McManus & Harris, 2021; Bury et al., 2020) has found that when visually moving through a structured virtual corridor, people feel they have moved further than when moving through a less structured environment. Here we test how the presence and texture of a ground plane affects perceived travel distance in a structured virtual corridor environment and a less structured "starfield" environment. Participants (n=22) saw a target at between 8 and 40 m that then disappeared, whereupon they experienced simulated forwards motion at 8m/s and indicated when they felt they had reached the target's previously viewed location. Data were analyzed in terms of gain (perceived travel distance/actual travel distance). Results show an effect of both ground plane texture (texture vs no texture) and environment type (structured vs unstructured), although no effect of the presence or absence of a ground plane. The starfield with the textured ground surface had the lowest gains, which we conclude may be a result of the lack of naturalism in this condition. In a follow-up experiment, we will investigate the effect of scale and naturalism on the perception of travel. Together these studies will have implications for the design of real and virtual environments where perceived motion is important and will enable us to further predict our perception of moving through these environments.

## #063 - Semantic congruency modulates the speed-up of multisensory responses

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Responses to multisensory signals are often faster compared to their unisensory components. This speed-up is typically attributed to target redundancy in that a correct response can be triggered by one or the other signal. In addition, semantic congruency of signals can also modulate multisensory responses, however, the contribution of semantic content is difficult to isolate as its manipulation commonly changes signal redundancy as well. To disentangle effects of redundancy and semantic congruency, here, we manipulated semantic content but kept redundancy constant. We presented semantically congruent/incongruent animal pictures and sounds, and asked participants to respond with the same response to two target animals (cats and dogs). We find that the speed-up of multisensory responses is larger for congruent (e.g., barking dogs) compared to incongruent combinations (e.g., barking cats). We then used a computational modelling approach to analyse audio-visual processing interferences that may underlie the effect. Our data is best described by a model that explains the semantic congruency modulation with a parameter that mostly affects the slow tail of response time distributions. The parameter was previously linked to trial sequence effects, which occur in our experiment from the repetition/switching of both sensory modality and animal target. We consequently discuss sequential effects as a potential contributor to the semantic modulation of multisensory responses.

## #064 - Vestibular influence on the audio-visual bounce effect

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As we know, the senses do not operate in a vacuum. While it has become popular to look at how the senses interact the vestibular sense is often overlooked. This study evaluated the neural underpinnings of the audiovisual bounce effect (ABE), a bistable illusion where participants have to judge if two identical objects crossing each other's paths seem to cross or bounce. The perception can be skewed towards a bounce perception if a sound is introduced at the point of coincidence. The neurological processes underlying this effect are not well understood. We used event-related FMRI and behavioral measures to evaluate these effects and show that sound-induced modulations of motion perception can be further modulated by changing the motion dynamics of the visual targets. By looking at the regions particularly activated by the different motion dynamics we see activation in the posterior parietal cortex and in the parieto-insular-vestibular cortical complex that correlates closely with behavioral results. These findings suggest that in the context of the ABE, the insular cortex plays a larger role than simply integrating sensory data. Instead it reflects the engagement of visuo-vestibular information, perhaps in the process of deriving a probabilistic perceptual solution.

## #065 - Age-related effects on proprioception and gait

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Age-related decline in proprioception has been linked to reduced mobility and increased fall risk in older adults. Proprioceptive acuity is often assessed using joint position matching (JPM). In the current study, we tested whether age-related proprioceptive decline and its link to gait can be revealed using the Pinocchio Illusion (PI), a proprioceptive illusion of one's arm and nose moving induced by stimulating the biceps tendon. We measured JPM error, susceptibility to PI, and gait during walking with a cognitive dual task (DT) or without (WO) in older (OA) and young (YA) adults. 42% of our participants perceived PI, from which age had no impact. We examined the effect of age group and illusion perceiver status on gait and JPM error. Compared to YA, OA had reduced cadence during the DT as well as reduced gait velocity and step length during both WO and DT conditions. Additionally, OA showed greater cognitive cost to cadence, as evidenced by a greater decrease in cadence during the DT compared to the WO condition. Compared to non-perceivers, PI perceivers had reduced cadence and step width in the DT condition. Neither age nor illusion perceiver status significantly impacted JPM error. A negative correlation was found between JPM error and cadence in both walking conditions suggesting proprioceptive decline is associated with impaired gait performance. Overall, we found age-related decline in gait but not in proprioception. Both increased JPM error and susceptibility to PI were associated with reduced cadence supporting the importance of proprioception for gait.

## #066 - Precision and Bias in the Perception of Object Size in Microgravity

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Gravity influences the perception of size although the mechanism remains unclear. Some authors have suggested that gravity might serve as a reference frame for visual judgements. If so, then in the absence of this persistent frame of reference size judgements should be less precise in microgravity. Twelve astronauts (6 women and 6 men) were tested before space flight, within 6 days of arrival on the ISS, approximately 90 days after arrival, within 6 days of return to Earth, and more than 60 days after return. They judged the height of a visually fronto-parallel square presented in VR at 6, 12 and 18m relative to a bar held in their hands aligned with the long axis of the body. The cube's height was varied trial to trial via an adaptive staircase. We found no significant differences in precision or bias between any of the space sessions and before they flew. However, when collapsing across test sessions, astronauts perceived the cube to be significantly larger in space than when upright ($p = 0.01$) or supine ($p = 0.017$) on Earth which was mainly driven by the cube being perceived as smaller ($p = 0.002$) after having been back on Earth for 60 days compared to their first session. The lack of effect of microgravity on precision makes it unlikely that the gravity-as-reference-frame hypothesis can explain posture-related perceptual size changes observed on Earth. However, space exposure does seem to create lasting changes in perceptual processing.

## #067 - Accuracy of perceived position of relatively rotating sound during passive body rotation

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Spatial hearing is considered a multisensory-integration process involving self-motion. While head rotation facilitates sound localization from the macroscopic perspective, recent reports have shown that head rotation itself negatively affects sound localization accuracy. During head rotation, the sound input to both ears changes according to the head movement. Therefore, the effects of head rotation and the change in the input sound are inconclusive in previous studies. In this study, we examined sound localization test with and without head rotation under the condition in which the change in sound input was identical. A circular loudspeaker array was installed in an anechoic room. A rotating chair was set at the center of the array. In the head rotation condition, listeners were passively rotated using the rotating chair, and the reference sound was presented from one loudspeaker. In the sound rotating condition, the reference sound was virtually rotated around the fixed listeners at the same velocity of the listener's rotation in the head rotation condition. At a certain timing, the target sound was presented from one loudspeaker around the position of the reference sound. Listeners were asked to judge whether the position of the target sound was rightward or leftward on the position of the reference sound. The results revealed that the sound position was largely biased in the sound localization condition compared with that in the head rotation condition; however, no significant difference in the degradation of the sound localization accuracy was found.

## #068 - Effect of postural instability on passable width perception in older adults

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Passable width perception is the perception of whether an aperture is passable. Previous studies have shown that passable width in older adults expands when walking and discussed larger body sway during walking in older adults, but did not directly investigate the effect of body sway. Here, we investigate the effect of body instability on passable width perception using one leg or tandem standing in younger and older adults. Participants wore a motion capture device for body sway measurement and maintained a posture, namely, both legs or one-legged (or tandem), standing 3 m away from a large display. The large display presented various aperture widths. The participants' task was to judge whether the aperture was passable without turning their shoulders. The proportion of passable response was fitted to the cumulative distribution function in each posture condition and the 50% threshold was defined as the critical margin. Body sway was calculated by averaging the shoulder's trajectory length per second in each participant. The results showed that the critical margin was larger in older than in younger adults, and larger in instable than in stable postures only in older adults. The results also showed that body sway was larger in instable than in stable postures, but no interaction was found between younger and older body sway data. The results suggest that older adults can have larger passable width and monitor the online status of their bodies to expand their safety margins.

## #069 - Adaptation to Visuomotor Delays and Its Transfer to Feedback Control of Reaching Movements

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To use multisensory feedback during movement, the brain needs to account for sensory processing delays. Previous studies have shown that the exposure to artificial delays leads to changes in movement planning. Here, we investigated if adaptation to visuomotor delays also influences feedback control of movements. We performed two experiments using a virtual Pong-Game with a robotic-arm. Participants moved the robot-handle with their right hand to control the movement of a virtual paddle to hit a ball. Over time, an increasing, artificial visual delay was added between hand and paddle movements (0ms, 50ms, 100ms, 150ms). Pong trials were randomly interleaved with reaching movements to a target. To test if feedback control mechanisms were affected by the adaptation to the delay, we probed feedback corrections to left- and rightward visual cursor jumps (exp. 1, N=16) or ±5N mechanical perturbations (exp. 2, N=16) during 50% of all reaches. During perturbed movements we removed the visual delay, but half of the unperturbed movements were performed with delay. In line with previous studies, performance in the Pong-Game decreased, and reach amplitudes increased with the size of the added delay. Conversely, removal of the delay resulted in a reduction of amplitudes. Interestingly, we observed an increase in the speed of corrective responses to visual perturbations during delay adaptation, but this effect was not present during force perturbations. These preliminary results suggest that the exposure to visual delays also influenced feedback corrections and that this influence might differ depending on the modality of the probed feedback circuit.

## #070 - Visual-to-auditory conversion methods for sensory substitution: sound spatialization only versus cross-modal correspondence

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Visual-to-auditory sensory substitution devices are assistive devices for the blind that convert visual images into soundscapes by mapping visual features with acoustic cues. These systems transform the spatial information of an acquired video stream into artificially spatialized sounds by reproducing natural acoustic cues that humans rely on to vocalize real sound sources. However, these methods have some drawbacks especially with elevation encoding. That is why the audiovisual cross-modal correspondence between pitch and visual elevation is often used by increasing the sound frequency with increasing elevation. The current study aimed at clearly establishing the potential benefits of using cross-modal correspondence for visual-to-auditory conversion. We investigated in a virtual environment the ability to perceive the location of an object where elevation is either conveyed using a spatialized white noise sound or using a pitch modulation of a spatialized tone. The task of the blindfolded participants was to point to a virtual target using the soundscapes, before and after an audio-motor familiarization with the encoding. Participants localized the target quite accurately even before having been familiarized with the conversion methods. Participants' performance to localize the elevation position was higher when the conversion method was based on pitch modulation rather than spatialization only. These results suggest a facilitation effect of the cross-modal correspondence between pitch and visual elevation that can benefit to the development of sensory substitution devices relying on pitch modulation.

## #071 - Path integration of blind individuals using uni-sensory feedback

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Blind individuals usually encounter difficulties walking around, given that vision is crucial for developing spatial navigation abilities. Path integration is a process that allows humans to navigate their environment by keeping track of their position based on the movements, the distance, and the direction they have traveled from a starting point. Furthermore, in the context of the development of assistive devices for navigation, it is not clear which sensory feedback might help blind individuals to move in the surrounding environment. Thus, this study aims to observe the effect of acoustic or haptic sensory feedback in a path integration task. Thirteen blind individuals were involved in the study. The task was divided into two conditions, randomly presented. In one condition, the participants walked along a straight line, by following a sound or with the experimenter's help. The other condition was a triangle completion task. The subjects reached with the help of the experimenter or alone by following two sounds on two of the triangle vertices. In both cases, the subject returned to the starting point alone. We evaluated the absolute error, that is the Euclidean distance between the starting and the point where the participant stopped. Results indicated that irrespective of the path, blinds made fewer errors in returning to the starting point in the haptic (i.e., accompanied walk) rather than the acoustic feedback. These findings have implications for the development of assistive technologies and training programs to support the navigation abilities of blind individuals.

## #072 - Investigating serial dependence in visual time perception

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Perceptual serial dependence is the attractive influence exerted by the past percepts on those happening in the present time; it contributes to the illusion that perception is a continuous phenomenon, despite the discontinuities that can occur during movements such as eyeblinks, saccades and so on. Serial dependence was found mainly in vision, in a variety of tasks involving different domains like numerosity, color discrimination, and orientation. Some studies found the effect of serial dependence also in time perception; however, they studied it correlated to other features. No previous studies have investigated the serial dependence of time perception in vision per se. The present study aims to search for the effect of serial dependency in a visual time duration discrimination task. To detect the serial dependency effect, the reference stimulus was kept at a fixed duration and presented before the test, whose duration was variable. Plus, a task-irrelevant “inducer” stimulus was presented before the reference. We hypothesized that, if serial dependence occurred, the inducer would affect the reference’s perceived duration. We tested for the “inducer” effect on the reference using Bayesian t-test. Results show that the “inducer” duration does not affect the reference stimulus duration, supporting the idea that serial dependence does not occur when time is the only variable at play: it is possible that previous effects found on time perception may be mediated by other domains, such as numerosity. Further investigations are needed to clarify such aspects and unveil the nature of serial dependence in visual time perception.

## #073 - Eye movement-related eardrum oscillations: signature of an active sensing process or epiphenomenon?

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Hearing is an active process and recent studies highlight how the ear is affected by cognitive states or motor actions. One example are movements of the eardrum induced by saccadic eye movements - known as "eye movement-related eardrum oscillations" (EMREOs). While these transient eardrum vibrations are systematically shaped by the direction and size of saccades, their consequences for hearing remain unexplored. We here studied their implications for sound detection in two ways: we investigated whether the occurrence of EMREOs shapes the detection of clicks presented before, during, or after saccades. Additionally, we further tested if EMREOs are shaped by cueing spatial attention prior to eye movements towards the location of sound targets. In our data, detection performance was not related to saccades or EMREOs, nor was the EMREO time course subject to attentional manipulation. We suggest that EMREOs play a role in shaping auditory localization cues based on binaural cues rather than in simple auditory tasks where monaural cues are sufficient.

## #074 - Audio-Visual Processing in Primary Visual Cortex by a Dynamical Model of Pyramidal Cell Computation

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Multi-modal integration in the brain is a distributed process. Recent evidence suggests that even primary sensory areas engage in direct multi-modal processing via cortico-cortical connections. Reports of multi-modal stimulation yield different consequences. For example, auditory influences on primary visual cortex showed to either suppress, not affect, or enhance neural firing rates, alter population tuning, or impact response latency. The kind of observation is thereby dependent on task, stimulus, and spatio-temporal resolution of the recording technique. Interpretation of these results directly impacts theories, such as predictive coding and biased competition, and so far, it is unclear, which neural mechanism could explain these phenomena altogether. We propose a neural model of pyramidal and interneuron computation, aiming to establish a mechanistic account of cortical integration. The model follows principles of dendritic integration theory, biased competition, and task-dependent thalamic gating. Inan audio-visual setting, primary sensory information enters the basal compartment of V1 cells and drives them into firing, while contextual auditory information from A1 enters apically and up-modulates the cell response, if the cell’s feature is task-relevant. Cells compete for selection within the population via inhibitory interneurons. We show by simulation how the different phenomena of multi-modal response alterations can be achieved supporting the whole range of observations. While large-scale measurements of population-level responses tend to report suppressed or unchanged firing characteristics, small-scale measurements of task-relevant subpopulations show signs of up-modulation. The proposed model offers utility for studying multi-modal phenomena and suggests direct consequences for their interpretation dependent on the resolution of measurement.

## #075 - The impact of sensory cues during multiple object tracking

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It has been documented that training with action mini-games does not only enhance attentional control functions in children, but also promotes the ability to integrate information from different sensory modalities (Nava, Föcker, & Gori, 2020). We modified an attentional control task, the so-called multiple object tracking task, and delivered visual, auditory, audio-visual and no cues during tracking in order to update the tracking pathways of the target objects (Föcker et al., 2022). More specifically, the target objects bounced against an inner orange circle and elicited a sensory cue when colliding with the central circle. Adults showed improved tracking performance when auditory and visual cues were presented irrespective of the task-load. By contrast, typical developing children (6-11 years old) mainly integrated visual cues during tracking whereas auditory cues did not promote tracking performance. To investigate the impact of sensory cues in those children who differ in multisensory perception from typical developing children, we asked autistic children to track the target objects while sensory cues have been presented. In contrast to non-autistic children, autistic children did not profit from any sensory cue presentation. We discuss possible underlying mechanisms of these findings such as cognitive load, multisensory integration abilities in children, transfer-effects to educational outcomes and outline future training designs.

## #076 - Higher order informational content: the perfect tool for multisensory research?

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Systems composed of many units, whose behavior goes beyond the sum of the individual behaviors of the singles, are ubiquitous. Examples relevant to what we do are the brain, the body as a whole, and the social systems we live in, and multisensory research is the optimal framework for this mindset. When it comes to analyzing collective behavior we are often stuck with pairwise dependencies (often correlations). In this talk I will describe a framework rooted in information theory to mine multiplets of variables sharing common information about the dynamics of complex systems, and provide some examples in neuroscience, physiology, and behavioral scores. I propose that widespread concepts such as integration, emergence, manifolds, dimensionality reduction, can be seen through the lens of information-based synergy. This framework seeks for higher order behaviors, in a complementary way with respect to mechanisms.

## #077 - Cross-modal active sensation in mice: Touching what you see

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Multisensory integration requires transformations between coordinate systems. In the mouse brain, tactile information from the snout's vibrissae reaches the somatotopically organized primary whisker somatosensory cortex (wS1) whereas the primary visual cortex (V1) contains a retinotopic map of the visual field. The rostro-lateral (RL) area of the posterior parietal cortex is a candidate cortical region to merge these representations. However, how converging multisensory inputs of nearby objects are processed in these cortical areas remains unclear. To address this question, here we investigate how neurons in mouse wS1, V1, and RL integrate visuotactile information about a pole in reach of the whiskers. Using two-photon calcium imaging, we record neurons across the posterior cortex in L2/3 of head-fixed mice. A pole is presented either in darkness or under illuminated conditions to separate visual, tactile and multisensory signals. We track whisker-pole interactions with a high-speed camera and record the gaze direction to reconstruct sensory signals at the periphery. We find that subsets of neurons in wS1, V1 and RL show selectivity for specific locations in the near space, with the highest fraction in RL. This location coding in RL is driven by both visual and tactile signals and depends less on whisker kinematics compared to wS1. By fitting shared-weight artificial neural networks, we are in the process of separating tactile and visual contributions to single-cell activities. Together, this suggests that object locations in the posterior parietal cortex are represented based on visual and tactile information, potentially in a shared reference frame.

## #078 - Auditory spatial localization in children: accuracy and precision along the azimuthal and elevation planes

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Sound localization is the ability to localize the position of a sound source. Several studies show that adults localize better sounds in the azimuthal (left-right) than in the elevation (up-down) plane. Similar studies on infants showed that performance for sound localization in the azimuthal plane improves during the first year of life. Nevertheless, it needs to be clear how sound localization varies along other planes. Here we investigated the auditory spatial localization skills of 22 sighted children aged three to five. Stimuli came from a device consisting of 25 speakers arranged in a 5x5 matrix. Participants were set at a distance of ~20 cm with the central speaker aligned with the nose. A pink noise sound was elicited randomly from one of four selected speakers (two on the vertical axis – elevation condition- and two on the horizontal axis – azimuthal condition). Responses were collected through tactile sensors placed on the device. We estimated accuracy (i.e., the distance of the response from the stimulus on the x- and y- axes) and precision (i.e., the standard deviation of the error on the x- and y- axes). Preliminary analysis shows that children have worse accuracy and precision in the localization of sounds on the y-axis, especially in the elevation condition. Our results on auditory spatial localization in children align with those already found in the literature on adults, suggesting a similarity in the performance between adults and children in auditory spatial localization.

## #079 - Using a hand-held tool modifies proprioceptive representations of the user's arm and tool

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Tools extend the functional boundaries of their user, allowing them to manipulate the world in previously impossible ways. Functionally extending the body with a tool has been found to alter sensorimotor representations of the user's arm and hand. Whether representations of the tool are also altered by tool-use has to our knowledge never been addressed. To close this gap, we developed a novel proprioceptive mapping paradigm that allowed us to simultaneously measure proprioceptive maps of the forearm and a hand-held tool (40 cm mechanical grabber). Participants judged the spatial location of proprioceptive landmarks on their forearm and tool (6 landmarks per surface; 12 landmarks in total; all hidden from view) in external space. We used linear regression to characterize each participant's proprioceptive forearm/tool representations before and after tool use. Their spatial judgments for each surface were modelled as a function of the actual spatial location of the proprioceptive landmarks. Interestingly, the proprioceptive representation of tool space was as accurate as the representation of forearm space. In contrast to prior findings, using a tool did not alter the spatial properties of these representations. However, the tool representation did become more precise after use. In sum, our results shed light on the nature of body and tool representations and their plasticity following tool use.

## #080 The boosted subjective time compression induced by enriching sensory feedback of a voluntary action

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Recent advances in automation technology can lead to unsafe situations where operators lose their experience of controlling the automated equipment, which has been referred as the sense of agency. Operators' sense of agency can be boosted by increasing automation but begins to decline when the level of automation is too much. Having operators keep their sense of agency, even when their opportunity for direct control is reduced, is a central requirement for the safe design of applications of automation. Recent evidence indicates that increasing the number of matches between predicted and actual action outcomes in performing a voluntary action contributes to more compression of the subjective time experience of the action outcome, enhancing the sense of agency. One idea to increase the number of opportunities to create the matches is providing enriched sensory feedback of the action. To investigate this hypothesis, using a temporal reproduction task in which participants reproduced the duration of an auditory stimulus to which they were previously exposed by performing a voluntary action with single or multiple auditory feedback, we examined how the subjective time experience of action outcomes changed with the amount of sensory feedback of the action. Results revealed that the subjective time compression induced by the voluntary action was boosted when the voluntary action was performed with multiple auditory feedback, enhancing the sense of agency over the action outcome. This finding can be useful for developing new techniques to have operators keep their sense of agency over the automated equipment.

## #081 - Visual bias on bimanual tactile perception: investigation of the neural mechanisms using neurocomputational modelling

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In the brain, visual and tactile modalities mutually interact and are exploited in spatial information processing. Moreover, interactions between these sensory systems also exhibit high specificity in spatial perception, which may reflect multisensory representations learned through visuotactile (VT) experiences. Recently, in a task requiring participants to detect unimanual and bimanual tactile cues, Wani and colleagues (2021) found a visual bias, which depended on brightness, on tactile perception. Notably, tactile performance remained biased after VT exposure, even when no visual cues were presented. These effects on bimanual touch conceivably reflect cross-modal learning resulting in a reorganization of brain's circuits involved in sensory perception and interhemispheric interactions. Nevertheless, the neural substrates modified by VT experience are still unknown. Here, we exploited a previously developed neurocomputational model (Magosso et al.,2010), capable of simulating VT spatial interactions, to test different hypotheses regarding potential network-level changes that may underlie the VT learning effects: 1) a hemispheric-specific reorganization of visual-tactile hand representations; 2) a stronger competition between the two hemispheres; 3) a combination of the two mechanisms. Simulation results indicated that VT learning effects are inconsistent with plasticity restricted to unisensory visual and tactile hand representations; but also, with changes restricted to the strength of inter-hemispheric inhibitory interactions. Instead, we found that both the hand representations and the inter-hemispheric inhibitory interactions need to be plastic to fully recapitulate VT learning effects. Our results imply that crossmodal learning of bimanual spatial perception involves multiple changes distributed over a VT cortical processing network.

## #082 - Visual-nociceptive integration during rubber hand illusion

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Body ownership refers to the subjective perception of the body as one's own. The classic way to study body ownership in healthy individuals is to use a perceptual bodily illusion known as the rubber hand illusion (RHI). In the classic RHI, a rubber hand in the participant's view is synchronously stroked with the real hand hidden behind a screen, which leads to an illusory sensation of the rubber hand as one's own. Previous studies have demonstrated that this illusory percept arises from the integration of vision, tactile and proprioceptive signals. However, little is known about the role of nociceptive input in body ownership and the RHI. We tested 180 naïve healthy volunteers across six different experiments in a 'nociceptive RHI' paradigm, where we manipulated the congruence or incongruence of visual impressions from the rubber hand and nociceptive stimulation on the participant's real hand. Brief radiant heat stimuli were delivered on participants' hand dorsum using Nd:YAP laser stimulator to specifically and selectively activate unmyelinated and thinly-myelinated nociceptive fibers. RHI was quantified with questionnaire ratings and by measuring the proprioceptive drift between the real and subjectively perceived position of the hand. We found that the nociceptive RHI could be elicited with synchronous and spatially congruent visuo-nociceptive stimulation according to the temporal and spatial rules of the classic innocuous RHI, suggesting that it was triggered by the integration of nociceptive, visual and proprioceptive signals. We conclude nociceptive information contributes to the multisensory experience of our bodies and the sense of body ownership.

## #083 - Does audio-visual information result in improved health-related decision-making and knowledge when compared with audio-only or visual-only information? A systematic review & meta-analysis

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Background: Making decisions about one's health can be difficult, especially for older adults, due to the quantity and complexity of medical information. Evidence suggests a multi-sensory benefit for older adults (Dieuleveult et al., 2017), therefore, the modality that health information is presented in may be important. Whether audio-visual information can enhance health-related decisions has not been explored using meta-analysis. Objective: To understand the efficacy of audio-visual health information for informing individuals' health-related decision-making, and improving health knowledge compared with audio-only or visual-only information. Methods: We searched 12 databases, and snowball sampled reference lists of articles. Both published and grey literature were considered. Studies were excluded if they were not reported in English. Randomised controlled trials (RCTs) were included if they compared audio-visual stimuli with an audio-only or visual-only stimuli and assessed the outcome; decision making. Eighty-five full-text articles were screened by 2 authors for inclusion. Data were extracted from 19 published RCTs. The Cochrane Risk of Bias tool was used to assess risk of bias. Authors were contacted for missing data. Results: Extracted data will be synthesised using meta-analysis; where quantitative data are not available, a narrative synthesis will be used. In preliminary analysis, the model (k=7) showed that decisional conflict was lower in the intervention groups (Audio-visual stimuli) compared to the control groups ( g = .13, 95%, CIs = -0.26, 0.10) but this was not significant p = .21. Analyses are ongoing and results will shed light on the most effective modality for presenting information to facilitate health-related decisions.

## #084 - The effect of physical motion on Human spatial memory and neural representations of space

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Spatial memory plays a key part in our everyday lives. Most recent research on spatial memory accuracy and its underlying neural representations has focused on tasks performed in screen based virtual environments. These environments have the advantages of being easy to work with, as they are flexible, controlled and cheap, and are easier to combine with human neuroimaging. However these tasks have an inherent limitation as participants are stationary, leading their activity to be based mainly on the visual sensory channel without the idiothetic channels recruited by actual movement. This might influence both spatial behavior and neural signals challenging the generalization of neural representations between these cases. Here a group of healthy participants (n=24) performed a matched spatial memory task in the real world using augmented reality (AR), and in a stationary screen based virtual environment (VR). A second group of patients (n=4) performed this task while undergoing intracranial neural recording from their hippocampus. We found that the healthy participants reported that the ambulatory AR task version was significantly easier, more immersive, and more fun than static VR. More importantly, their performance was twice as accurate, showing a significant advantage in spatial memory accuracy when integrating idiothetic channels with vision. The patient data also enabled the replication of several neural representations of space from animal models. Our findings demonstrate the importance of actual physical motion to spatial research in humans and demonstrate the potential of combining augmented reality paradigms with ambulatory intracranial recordings.

## #085 - Auditory pitch modulates the localization of audiotactile stimuli during active touch

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Movements can impact tactile sensations and modulate multisensory interactions, making participants vulnerable to the interference of non-informative auditory stimuli. Studies on cross-modal correspondences have shown that humans tend to associate higher-pitched sounds with higher tactile spatial positions. However, studies investigating such multisensory interactions have all been conducted in conditions of passive touch. To explore whether pitch may modulate the perceived location of a tactile stimulus experienced during active touch, we asked participants to slide their index finger twice against a horizontal haptic display and judge the vertical position of a target audio-tactile stimulus (second slide) relative to a reference audio-tactile stimulus (first slide). The reference audio-tactile stimulus was always associated with a pink-noise sound, while the tone of the target audio-tactile stimulus differed between 3 experimental conditions: neutral (pink noise); high pitch (6 kHz tone); and low pitch (800 Hz tone). There were 210 trials in total, 70 per condition interleaved into three blocks. The psi-marginal adaptive method was used to optimize stimulus placement and estimate the threshold and slope of the psychometric function for the three conditions. We found a relationship between auditory pitch and perceived location of the audio-tactile stimulus, with the high pitched sound biasing perception of the tactile stimuli towards higher locations on the screen. We found no significant differences in the slope between conditions. The present results suggest that pitch can bias tactile perception in active touch conditions.

## #086 - Interhemispheric asymmetry of visual evoked potentials underlies crossmodal interaction between nociception and vision

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Behavioral studies repeatedly evidenced that nociceptive stimuli can affect the perception of external visual information near the stimulated body part. We investigated neurophysiological mechanisms of such crossmodal interaction between nociception and vision. We hypothesized that nociceptive stimuli could influence cortical visual pathways, and more specifically the interhemispheric asymmetry of brain responses to lateralized visual stimuli. 28 healthy participants made temporal order judgements (TOJs) on pairs of light flashes presented one in either side of space with different onset asynchronies. They were shortly preceded by an electrical nociceptive stimulus randomly delivered to the left or right hand. We compared the amplitude of the event-related potentials (ERPs) to simultaneous bilateral visual stimuli between the two hemispheres. TOJs were significantly biased towards perceiving the light on the side of the nociceptive stimulus as having flashed earlier than the light on the opposite side. Mean amplitude of the visual ERPs was significantly larger over the hemisphere contralateral to the side of the nociceptive stimulus, relative to the response over the ipsilateral hemisphere, mostly over parietal-occipital area at 120-200 msec after bilateral lights' onset. Greater behavioral TOJ bias correlated with greater interhemispheric asymmetry of the visual ERPs. This data shows that nociceptive stimuli can boost cortical processing of visual stimuli at a relatively early latency in extra-striate areas, possibly acting on the visual dorsal stream. This effect is thought to index cortical mechanisms by which one's attention is automatically drawn towards the portion of visual space surrounding the body part that receives nociceptive input.

## #087 - Assessing and Optimising Audio-visual Integration for Listening

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It is well established that lipreading benefits listening in noise (Sumby & Pollack, 1954). Audio-visual temporal coherence can also help listeners segregate competing sounds more effectively (Maddox et al., 2015). This study's aim was to assess whether the benefit of seeing a talker's face is fully explained through lipreading, or whether visualising mouth movements also provides temporal coherence cues that potentially help listeners segregate competing sources more effectively. We used a speech-in-noise task involving the identification of two target words (a colour and a noun) in a carrier sentence in the presence of two masker speakers. We measured speech discrimination thresholds while presenting the sound mixture accompanied by a naturalistic video of either the target talker or one of the masker talkers (condition 1). We separately measured participants' ability to use vision for streaming by presenting the video of either the target talker or a masker but freezing the talker's mouth for the duration of the target words (condition 2). Finally, we measured performance with audio and a still frame of either the target talker or a masker (condition 3). In addition to the speech-in-noise testing, we are also measuring participants' hearing thresholds and ability to lipread. Results from 125 participants (aged 18-85, 88 normal hearing, 37 with hearing loss) suggest that both condition 1 and 2 offer an advantage over the static image in normal hearing listeners. Analysis is ongoing, but preliminary results suggest that increasing age and/or hearing loss diminish the advantage offered in condition 2.

## #088 - Radiant thermal signals give rise to a contactless rubber hand illusion

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Illusions of body ownership, such as the rubber hand illusion (RHI), can provide some insight into the interplay between vision, proprioception, and touch during processes of multisensory integration. Previous studies investigated the modulation of some characteristics of the tactile input, for example velocity, softness, and temperature. However, the contributing role of thermal signals to the sense of body ownership, over and above tactile stimulation, remains unexplored. Here, we induced a contactless RHI (n=33), whereby visual and radiant thermal signals were combined to give arise to an illusion of body ownership towards the rubber hand in absence of tactile stimulation. Participants looked at a beam of light on a realistic rubber hand, which was moved in synchrony or out of synchrony with a heat lamp placed on top of the participants' own hidden left hand. Our results showed that the synchronous activation of thermoreceptors on the real hand and visual stimulation on the rubber hand was successful in inducing an illusion of body ownership, as measured with self-report questionnaires. Participants also perceived the source of heat as closer to the rubber hand as compared to the asynchronous condition (i.e., thermal drift). The illusion was abolished when substituting the heat lamp with a normal lamp, and when the rubber hand was placed in an implausible position, ruling out the possibility that such effects were due to visual or cognitive expectations. Thus, thermosensation plays an important role to the way we recognise our body as our own, even without tactile stimulation.

## #089 - The cognitive mechanisms underlying the variation of McGurk illusion susceptibility

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The McGurk illusion has been widely used as a reliable tool for measuring audiovisual speech integration in numerous studies. However, recent research has shown that there is significant variability in its susceptibility, leading to concerns that it may not be an accurate measurements of audiovisual speech perception. In this study, we investigated the cognitive mechanisms underlying the within-participant variation (experiment 1) and between-participants variation (experiment 2) of the McGurk illusion. In experiment 1, we tested the within-participant variation of the McGurk illusion susceptibility on 36 participants using audiovisual syllables recorded from 20 speakers and found that the illusion susceptibilities (0.3 ~0.9) varied across speakers on the same participants and were positively correlated with the visual accuracy ($r= 0.41$, $p<0.05$). Moreover, syllables from different speakers shared similar phonological features (F2 and F3) and articulation features (changes of the mouth area over time) induced similar McGurk illusion susceptibilities. In experiment 2, we tested the between-participants variation of the McGurk illusion and its stabilities on 139 participants and found that illusion susceptibilities varied widely among participants but were stable over time (2 weeks: $r = 0.66$, $p<0.01$; a year: $r =0.81$, $p<0.001$). Additionally, the illusion susceptibilities were positively correlated with visual accuracy ($r =0.20$, $p<0.05$) and were negatively positively correlated with auditory accuracy ($r=-0.30$, $p<0.001$). These findings suggest that the variations of McGurk illusion susceptibility represent flexible and stable audiovisual speech ntegration according to the reliability of the unisensory speech signals.

## #090 - Immigration modulates audiovisual emotion integration in adults: the effect of the host culture and migration itself

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Individuals from Western cultures are known to have a tendency for face-dominance in the audiovisual emotional processing of faces and voices, whereas those from East-Asian cultures have a tendency for voice-dominance. However, it remains unclear how these tendencies change when people migrate from one culture to another. The present study aimed to investigate whether immigrants adopt the shared tendency of the host culture during audiovisual emotional processing or whether common changes associated with immigration (e.g., second language acquisition) produce the same modification regardless of the destination. Immigrants to Japan from Western countries exhibited a further decrease in the voice-dominance tendency, a modification in contrast to the tendency observed in Japanese culture, suggesting that immigration itself is the more relevant factor. This modification in audiovisual emotional processing can be explained by the inhibition of the unimodal process of emotional prosody during second language acquisition, and/or by increased reliance on facial expressions when exposed to individuals of a different ethnicity.

## #091 - Plasticity of word processing networks in brains of congenitally blind individuals

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All over the world, language processing involves similar brain regions. Intriguingly, one population escapes this universal pattern - in blind individuals, linguistic stimuli activate not only canonical language networks, but also the “visual” cortex. Theoretical implications of this finding are still debated. First, it is unknown what properties of linguistic stimuli are represented in the blind visual cortex. Second, it is unclear how blindness influences linguistic representations beyond visual areas, particularly in the canonical language networks. To address these questions, we enrolled congenitally blind and sighted participants in an fMRI experiment, in which they listened to concrete, abstract, and pseudo nouns and verbs. We used multi-voxel pattern classification to reveal brain representations of word grammatical class (nouns/verbs), concreteness (abstract/concrete words), and lexicality (abstract/pseudo words) in the two groups. We found two types of representations in the blind visual cortex only - the word concreteness was represented throughout the visual cortex in this group, whereas the word grammatical class was represented solely in motion-sensitive areas. The word lexicality was represented in visual areas in both blind and sighted participants. Beyond the visual cortex, we observed plasticity of word representations in many canonical language regions in the blind, such as left frontal and temporal cortices, or the precuneus. Overall, our study shows how specific linguistic properties of spoken words are represented in the visual cortex of blind individuals. Furthermore, it demonstrates that representational plasticity of the visual cortex in this population goes hand in hand with reorganization of canonical language networks.

## #092 - The subjective experience of using a newly-learned cue

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People can combine sensory cues to enhance the precision of their perceptualjudgements, known as cue combination. Recent work also shows that people receive these cue combination gains with a newly-learned cue. However, how an individual's subjective experience changes when their perception is supplemented with a novel cue is poorly understood. We tested this in a depth perception task, using familiar (binocular disparity, size) and novel (auditory pitch) cues to depth. Participants judged which of two objects presented sequentially was closer across unimodal and bimodal (disparity and size, disparity and pitch) conditions. Alongside psychophysical measures of perceptual precision, we collected open responses to questions about participants' subjective experiences with the stimuli. Responses were analysed using a mixed data- and theory-driven thematic analysis and interpreted alongside psychophysical data. Several key themes were identified, including: i) re-evocation of non-present stimuli; ii) awareness of cue combination-related gains; iii) attention/automaticity; and iv) cue-switching. Re-evocation, the internal replay of past experiences, was reported for all cues, including the new audio cue. Most participants reported using a second cue when depth judgements were uncertain. A reduced requirement for attention was reported when using two cues in combination. Several of these phenomena were also good predictors of psychophysical performance gains. These qualitative data are beginning to give us an understanding of people's subjective experiences as they learn to use new cues during multisensory perception. More broadly, this approach shows the value of combining qualitative and quantitative measures to understand processes of multisensory perception and learning.

## #093 - The effect of postural orientation around the pitch axis on the haptic perception of vertical

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The subjective haptic vertical (SHV) is the estimate of vertical provided by touch and proprioception. The SHV is influenced by posture but although the effect of postural changes around the roll axis has been well studied, rotation about the pitch axis have been less investigated. Here, we look at the effect of pitch angle, gender, and serial dependence. Blindfolded participants (21 males, 21 females) sat in a rotatable chair. They made SHV estimates at seven orientations between 45° and 135° in 15° steps presented in a randomized sequence. After a 30-second adaptation period, they aligned a rod mounted on the chair level with their hand, to their perception of gravitational upright. The rod's start position was set randomly by a motor for each of ten repetitions. Results were analysed using a linear mixed model with gender, tilt, and serial dependence as fixed effects. Participants systematically mis-estimated the perceived vertical with a tendency to push the top of the rod too far toward the feet. This bias became more pronounced and settings less precise at tilts further away from body vertical (figure 1). A strong gender effect was found in which women showed smaller biases than men. Serial dependence also affected the SHV: errors were less when the previous orientation had been towards one or other end of our tested range. Our results imply a general overestimation of perceived pitch and show gender and sequence effects that could be highly relevant in situations where accurate estimations of pitch are important.

## #094 - Probabilistic computations in body perception

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To position the distal part of a limb, such as the finger, the brain needs to work out the geometry imposed by the respective joint angles and the lengths of the phalanges (Fig1A). Proprioceptive and kinetic feedback, and feedforward predictions from motor signals, all give information about the joint angles, while phalanx length information may only rely on learnt information, stored in the brain. All these sources of information are noisy. While it has been suggested that the brain relies on Bayesian inference to deal with noisy signals, there is no such model that allows to quantify and experimentally test fine grained predictions on limb position perception. Here, we developed a formal model of finger position estimation based on the Bayesian integration of sensory likelihoods and priors over joint angles and phalanx lengths. The model generally predicts biased perceptual estimates as a function of postural variations and the associated sensory noise, under the assumption of a constant prior on joint angle. If the integration is performed in transformed, external (Cartesian) coordinates, priors over angles lead to perceptual biases in finger geometry, despite unbiased priors over length (Fig1B). We tested the model by asking twenty participants in VR to indicate the perceived position of their joints and fingertips using a virtual pointer, while keeping the hand at different postures. MLE results (e.g., Fig1C) provide evidence that body perception can be well described by Bayesian computations in external space. This model can be used to test further predictions regarding body perception in multisensory environment.

## #095 - The Effect of Stimulus Complexity on Perceived Simultaneity in Virtual and Augmented Reality

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Measuring to which degree signals that come from the same event are perceptually integrated is fundamental to understanding everyday experiences, so as to recreate them in virtual environments and augmented reality content. For this, audio-visual synchronization is particularly important, but it is often studied under controlled laboratory conditions and with very simple stimuli. However, both a wider range of latencies and a different type of sensory processing could occur with more complex natural stimuli that involve, for example, visible avatar actions and auditory consequences of those actions. The current study investigates the limits of perceived audio-visual simultaneity in VR (opaque head-mounted display) and AR (see-through head-mounted display) with stimuli of different complexities. We showed participants a pair of simple (e.g., tone beep and flashed dot) or complex (e.g., a violinist playing a musical note) audio-visual stimuli, asking them to report simultaneity vs. asynchrony as a function of different audio and visual delays. Results indicate perceptual in both AR and VR that sounds must be presented earlier for the multisensory events to be considered simultaneous. This bias is more substantial with complex stimuli displayed in AR. Moreover, participants give more precise synchrony judgments with simple stimuli. These findings characterise the pattern of simultaneity judgments which should be considered in creating virtual and AR content.

## #096 - Influence of touch duration on tactile localization on the body

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When a nuisance on our skin bothers us, we reach to stop it without looking thanks to our ability to do tactile localization. In adults, this has predominantly been studied with short stimuli that extinguish before participants can reach them (e.g., Fuchs et al., 2020). In a more ecological situation the touch would last until we reach it. In the study presented here we compare localizing temporary and continuous vibrotactile stimuli (on the forearm, upper arm and lower leg). We expected better performance with continuous stimuli because pointing to them does not require retrieving their location from memory. A second expectation concerned the effect of landmarks. In some studies, body landmarks (e.g., wrists, elbows) facilitate tactile localization in their vicinity (e.g., Cholewiak & Collins, 2003). In our preliminary pilot study (4 participants), first, contrary to our predictions, the temporary vibrotactile stimuli were localized at least as precisely as the continuous stimuli. Second, curiously, tactile localizations seem biased away from body landmarks, showing no improvement in accuracy. The unexpected results could be due to insufficiency of data. A possible explanation of the first preliminary result might be that since vibrations travel away from the stimulus, they blur stimulus locations, particularly in case of continuous stimuli. Concerning the second preliminary result, locations near landmarks could be “noisier” because bones, tendons and ligaments around them conduct vibrations better compared to softer tissues elsewhere. Full experimental results will be ready before the conference and shed more light on these unexpected preliminary results.

## #097 - Multi-modal sensory selection assay in mice to explore underlying neural circuits

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A daily challenge is to process signals from multiple senses and to prioritize the most behaviorally relevant signals over less important ones. Referred to as selective sensory processing, this critical function is disrupted in a range of neurodevelopmental disorders. Neuroimaging and neurophysiological studies have outlined two major hypotheses of selective multisensory processing. One hypothesis suggests sensory selection is driven by cortico-cortical interactions, and a complementary view suggests a mediating role for the thalamus in guiding these cortico-cortical interactions. However, recordings spanning multiple cortical regions coupled with thalamic neural activity measurements and manipulations that could provide insights on the underlying mechanisms of sensory selection are lacking. Therefore, in this project we aim to assess the coordinated activity across sensory and association cortical regions and the role of the thalamus in these interactions. To achieve this goal, I have developed a well-controlled multisensory learning assay in head-restrained mice which allows characterizing sensory responses to visual and/or tactile stimuli across the cortex under different behavioral relevance. In this paradigm, behavioral relevance is defined by reward contingency with either of the sensory modalities at a time. We demonstrate that mice can learn the visual reward contingency within 4 weeks and adapt to the switch in rewarding modality within 2 weeks. Our preliminary findings from cortex-wide calcium imaging suggest differential processing of sensory signals under differential behavioral contexts. These experiments are the first steps towards the goal of characterizing multi-area and cellular level interactions and probing the role of thalamus using optogenetic approaches.

## #098 - Nihil in intellectu nisi prius in sensu?: Knowledge and conceptualisation of olfactory information without the sense of smell

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“There is nothing in the intellect that was not first in the sense”. This famous quote, attributed to Aristotle, represents the foundation of the empiricist view on how knowledge arises in the human mind. If true, one may therefore wonder how sensory deprived people conceive the things they cannot experience with their senses. The study of people born without olfaction represents a particularly interesting case to tackle such a question for two main reasons: 1) smell is a sensory quality that does not easily “remap” onto other properties of the other senses (e.g. you cannot see, hear or touch smell) and 2) because it has been demonstrated that, compared to the other senses, olfactory information is poorly accessible through language. How do people born without smell conceive olfactory information? To address this question, we asked congenital anosmic participants (N=20) and matched controls (N=20) to categorise and sort words with various olfactory values across five different tasks (property generation; card sorting; odd-one out; drag and rate; knowledge of the words) and two different conditions (neutral and olfactory). Our results show that despite important similarities between congenital anosmic and control people, they nonetheless show interesting qualitative discrepancies on how they think about olfactory content of things. Our study suggests that language allows a deep representation of odors even without ever experiencing them. However, such representation differs from the one of control people in significant ways, showing how sensory experience partially shapes our mental representation of the things we experience.

## #099 - Tracking occluded multisensory objects

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Predicting the location of moving objects is essential in day-to-day behavior, for instance when participating in traffic. Working memory helps keeping track of moving objects, despite temporary sensory interruption. Although many objects provide multisensory information, it remains unknown whether tracking occluded objects benefits from maintenance of multisensory (compared to unisensory) information. To test this, we developed a novel paradigm. In each trial, an auditory, visual or audiovisual target moved horizontally at a constant speed from left to right. At varying timepoints, the moving target was occluded by an audiovisual occluder. After varying delays, the occluder disappeared and participants had to indicate where the target should be when the occluder disappeared. We analyzed the mean horizontal localization error and its precision in the context of a Bayesian optimal integration model. In terms of localization error, audiovisual targets were not localized more accurately than either unisensory target. In terms of precision, audiovisual targets yielded more precise localization than auditory targets, but did not differ from visual targets. Moreover, localization performance for audiovisual targets was worse than expected by optimal combination of the unisensory inputs. The current results suggest that auditory and visual inputs were not integrated in working memory, deviating from an optimal integration model. Even though unisensory auditory and visual inputs of the same object both contained useable location information, participants seemed to track audiovisual targets based on visual information alone. Taken together, humans do not seem to benefit from maintaining audiovisual information in working memory when tracking audiovisually occluded objects.

## #100 - Potential dissociation between pain perception and the modulation of pain-related ongoing neural oscillations

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Recent investigations using intracerebral EEG in the human insula found that stimuli delivered in a slow sustained periodic manner are being preferentially processed for thermonociceptive over vibrotactile stimuli. In this study, we aimed to assess whether this preferential modulation is an insular-specific phenomenon and whether cognitive processes known to influence pain perception - such as distraction - also influence these modulations. A 64-channel EEG cap was used to record neural activity in 25 healthy participants and stimuli were delivered at a frequency of 0.2 Hz. Participants were instructed to rate the level of perceived stimulus intensity on a visual analog scale after each trial. Linear mixed models were used to assess the effect of stimulation modality on intensity rating, phase-locked EEG signal and modulation of ongoing oscillations at the frequency of interest. Our findings revealed that thermonociceptive stimuli led to significantly higher ratings of perceived stimulus intensity than vibrotactile stimuli. Interestingly, the phase-locked EEG exhibited a larger modulation for vibrotactile stimuli, displaying a dissociation between perception of intensity and magnitude of modulation. However, ongoing oscillations in the theta, alpha and beta frequency band showed a significantly smaller modulation related to vibrotactile than to thermonociceptive stimuli. While the intensity rating was lower during the distraction task, no significant differences were found in the modulation of ongoing oscillations. This investigation confirms that the preferential modulation of thermonociceptive stimuli is not limited to the insula. Yet, our results suggest that they do not necessarily reflect the experience of pain.

## #101 - Enhancing Learning Outcomes through Multisensory Integration: An fMRI and DTI Study of Audio-Visual Training in Virtual Reality

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The integration of information from different sensory modalities is a fundamental process in the brain that enables the modification of behaviour and the enhancement of perception. This study investigated the effects of a four-week multisensory training program utilizing virtual reality (VR) on brain activity and microstructure, as well as cognitive performance. The study included twenty healthy participants who completed a 30-minute daily training program on VR, utilizing a 'scanning training' paradigm commonly used in hemianopia rehabilitation. Neuroimaging data, performance data, and laboratory tests were collected at baseline, after two and four weeks of training, and four weeks post-training. The results showed that incorporating spatial auditory cues to voluntary visual training in VR led to measurable performance gains that apply to both involuntary and visual search conditions. Behavioural data analysis revealed significant improvements in behavioural performance, including faster task completion time and higher scores over time. Additionally, functional and structural neuroimaging data analysis demonstrated increased functional activation in multisensory brain regions involved in early-stage audio-visual processing and microstructural changes in the optic radiation and superior longitudinal fasciculus II, key white matter tracts involved in multisensory integration.The results of this study demonstrate that adding spatially and temporally congruent auditory cues to voluntary visual training in VR leads to augmented brain activation and microstructural changes in multisensory integration, resulting in measurable performance gains and learning transfere to involuntary and visual search conditions. This study highlights the potential of VRbased multisensory training as an effective method for enhancing cognitive function and as a valuable tool in rehabilitative programs.

## #102 - Only visible flicker helps flutter: Tactile-visual integration breaks in the absence of visual awareness

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Combining information from multiple senses enhances our perception of the world. Yet, whether we need to be aware of all stimuli to benefit from multisensory integration is still under investigation. Here, we tested whether tactile frequency perception benefits from the presence of congruent but perceptually fused and thus invisible visual flicker. Our participants completed a tactile frequency discrimination task given either unisensory tactile or congruent tactile-visual stimulation. Tactile and tactilevisual test frequencies ranged from far below to far above participants' flicker fusion threshold (determined separately). For frequencies distinctively below their flicker fusion threshold, participants performed significantly better given tactile-visual stimulation than when presented with only tactile stimuli. Yet, for frequencies above their flicker fusion threshold, participants' tactile frequency perception did not profit from the presence of congruent but likely fused visual flicker. The results matched the predictions of an idealobserver model in which tactile-visual integration is conditional on awareness of both stimuli. In contrast, it was impossible to reproduce the observed results with a model that assumed tactile-visual integration proceeds irrespective of stimulus awareness. In sum, we revealed that the benefits of congruent visual stimulation for tactile flutter frequency perception depend on the visibility of the visual flicker, suggesting that multisensory integration requires awareness.

## #103 - How are visuo-haptic object categories formed during childhood?

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Recent research has provided evidence for the organisation of multisensory object representations into category specific knowledge. However, it is not yet clear at which developmental stage these crossmodal interactions underpinning object categories arise. In contrast, evidence for adult-like multisensory integration in perceptual tasks appears to develop in late childhood. Here we aim to elucidate the age at which children integrate information across sensory modalities to form multisensory object categories. Children aged 4-12 years (N = 198) conducted a category learning paradigm, with each child allocated to one of three object learning conditions: visual-only; haptic-only; and visuohaptic. Specifically, children were presented with a set of novel objects to explore comprised of features which were either informative or uninformative of category membership. The efficacy of perceptual learning across these sensory conditions was assessed via learning criterion. Visuohaptic categorisation performance was then assessed using behavioural measures of accuracy and reaction time. The results revealed progressive enhancements to category learning performance across age, with children under age 6 displaying difficulty reaching the learning criterion. Analysis of learning condition further revealed haptic dominance in younger children's category learning. A benefit for multisensory integration was observed in the oldest children (10+ years) only. These findings align with the existing literature and provide additional insight into the categorisation of visuohaptic objects of relative complexity. Our findings provide novel insights into the learning of multisensory objects and the formation of multisensory object categories across development.

## #104 - Functional implications of a patch/matrix-like compartmental organization in the mouse inferior colliculus

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The inferior colliculus (IC) is an obligatory relay station and massive convergence center for auditory information. In addition to its role in sound processing, the IC receives multisensory inputs and is implicated in acoustico-motor behavior. The lateral cortex of the IC contains a network of neurochemical modules that subsect this structure into discrete processing regions: somatosensory inputs to the IC target these modules, while auditory inputs target complementary extramodular zones. While these auditory inputs have been shown to mediate diverse functions, the role of somatosensory inputs to the IC is unknown. To test the hypothesis that these somatosensory inputs gate auditory information processing, we trained mice to perform a go/no-go task in which they lick for a water reward after presentation of a noise target, with the goal of then selectively activating somatosensory inputs to the IC on a subset of behavioral trials to determine how this affects target detection. In addition to assessing the functional role of somatosensory inputs to the IC, we used two-photon imaging to determine the sound response properties of neurons in modular and extramodular regions of the IC. Preliminary data suggest that mice can learn the go/no-go task paradigm with high accuracy following ~3 weeks of training. Two-photon imaging of IC responses to pure tones, FM sweeps, noise, and vocalizations was successfully performed. The results of the experiments will determine what effect somatosensory input to the IC has on sound detection and whether modular and extramodular regions of the IC have distinct sound processing features.

## #105 - Multimodal integration of emotional robotic stimuli: a reaction time study

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Socially Assistive Robots (SARs) are currently being considered as intervention tools for autistic children, with mixed findings regarding their efficacy (Kostrubiec and Kruck, 2020). Despite this, research into the understanding, perception, and processing of SARs relative to humans remains sparse. This area of research may offer insights that can inform the design of future interventions. Previously, it has been found in human emotional stimuli that the presentation of stimuli to multiple congruent modalities can facilitate processing relative to unimodal stimuli (Collignon et al., 2008), whereas when multimodal information is emotionally incongruent, processing is attenuated (Föcker et al., 2011). We investigated whether this aspect of multisensory processing in humans is also reflected in the processing of SARs. We hypothesized that when SAR stimuli were emotionally congruent SAR, processing would be facilitated relative to unimodal stimuli, and that emotionally incongruent SAR stimuli would result in attenuated processing. Ninety five participants aged 16-64 (M = 26, SD = 12.42) completed a reaction times task to emotionally congruent, incongruent and unimodal robotic stimuli. Inverse efficiency scores were lower, and drift rates were faster for emotionally congruent stimuli compared to emotionally incongruent stimuli, indicating enhanced processing of congruent stimuli. Results indicate that there are similarities between the processing of human and robotic emotional stimuli, which gives confidence in the use of SARs in the context of autism interventions and the transfer of improvements in targeted social behaviours from SARs.

## #106 - Older adults do not show enhanced benefits from multisensory information on speeded discrimination tasks

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Research has shown an age by modality interaction in low-level discrimination tasks, such that older adults benefit more from multisensory information than young adults. However, more recent evidence has shown that the multisensory age benefit varies considerably across tasks. In the current study, older (65 – 80) and young (18 – 30) participants (N = 191) completed a leading speeded discrimination task (decision on whether a red or blue stimulus is presented) either online (Experiments 1 and 3) or face-to-face (Experiment 2).We examined whether presenting stimuli in multiple sensory modalities (audio-visual) instead of one (audio-only or visual-only) benefits older adults more than young adults. Across all three experiments, a consistent speeding of response was found in the multisensory condition compared to the unisensory conditions for both young and older adults. Furthermore, race model analysis was used to analyse response times using cumulative distribution functions (CDFs) to control for the redundant nature of multisensory information. Overall, the multisensory benefit was greater than that predicted by the race model with a significant benefit across a broad temporal interval, and peak multisensory enhancement of 4.4%. Critically, there were no significant differences between the CDFs of the young and older adults. Taken together, these findings provide strong evidence in favour of a multisensory benefit that does not differ across age groups. The results indicate that the use of multiple sensory channels improves cognitive processing for both young and older adults.

## #107 - Efficient adaptive classification of observers into distinct and diverse categories

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In psychophysics, adaptive methods typically optimize the efficiency with which a quantitative characteristic of sensory/perceptual performance (e.g., the threshold of the psychometric function, PF) can be determined. However, when the objective of testing is to categorize an observer into one of multiple distinct categories (e.g., different clinical populations) usage of these methods requires a two-step approach: First, estimation of the observer's performance on the continuous scale is optimized using the adaptive method, then a cut-off criterion performance is used to categorize the observer. However, this two-step process does not optimize the categorization of observers into distinct categories directly. A notable exception to this approach was proposed by Cobo-Lewis (1997, Percept Psychophys, 59, 989) who devised a method that directly and explicitly optimizes the categorization of observers into distinct categories. However, this method has the limitation that fixed values must be assumed for the parameters of the psychometric functions that typify each category. Here, I combine aspects of the psi-marginal method (Prins, 2013, J. Vis., 13, 3) and the Cobo-Lewis method in order to optimize the classification of observers into distinct but diverse categories directly without the need to assume fixed values for any parameters. The proposed method is validated using simulations as well as human psychophysical testing in which the (simulated) categories of observers differ with respect to the PF's location, slope, or both. The method is shown to require fewer trials to reach equivalent classification accuracy levels compared to a method that explicitly optimizes estimation of the PF parameters.

## #108 - Inducing Food Craving Using Multisensory Exposure In Indian Population

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In this study, we explored food craving mechanisms in Indian population by subjecting participants to multisensory exposure and food cues using local food items. We have used two categories of food namely sweet and savory. Participants were presented with food cues before and after multisensory food exposure and their desire rating and willingness to pay (measured with bidding rating) for particular food items were recorded separately. Corresponding EEG signal was recorded and analyzed to explore the differential neural activities between preexposure and postexposure conditions. Thirty adults (N = 30, 16 female, ages: 18-29, mean: 21.6, std: 2.67) participated in the experiment. FCQ-S value increased after the completion of the experiment, indicating an inducement of a food craving-like state throughout the experiment. For the exposed food item, postexposure desire, and bid value increased as compared to preexposure desire and bid values for both sweet and savory categories. For the non-exposed food item, the postexposure desire value decreased as compared to the preexposure desire value only for sweet category. No gender bias in food craving was observed for any of the participant categories. Participants showed higher P200 amplitude postexposure to sweet items, indicating increased early sensory attention. Participants also showed higher LPP amplitude postexposure to sweet items, indicating increased extended attention allocation for sweet food items. Our analysis demonstrated the role of multisensory food exposure in inducing craving. The craving effect was more prominent for the sweet food items but unlike previous studies, it cannot be attributed to gender bias.

## #109 - Individual differences in subjective and objective measures of auditory, visual, tactile and cross-modal sensory sensitivity

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*Individual differences in sensory sensitivity have been found across clinical and nonclinical populations, and may provide insights into risk factors for and aetiology of psychopathology. Sensory sensitivity has typically been examined using either phenomenological methods that investigate subjective experiences, or objective psychophysical methods that probe their underlying basic perceptual processes. Little work has combined these approaches, leaving unclear to what extent 'subjective' and 'objective' sensitivity are related, and whether inferences about one dimension can be drawn from measurement of the other. Similarly, few studies have examined withinindividual sensitivity or interactions across sensory modalities. We administered a range of subjective sensory sensitivity measures to 434 non-clinical participants (71.4% female, mean age = 19.31, SD = 2.41), who also completed a battery of psychopathology self-reports. We found moderate to strong correlations between sensitivity measures across sensory modalities. Associations between sensitivity and psychopathology measures ranged from weak to moderately strong, indicating potential modality-specific differences in sensitivity-symptom relationships. Objective auditory, visual and tactile sensitivity was then assessed in a subsequent sample using psychophysical adaptive staircase paradigms to probe individual perceptual thresholds for each modality, and an audio-visual paradigm to assess cross-modal integration. Evidence of substantial inter-individual variability in thresholds for each modality was found, with correlations between modalities and with subjective measures suggesting there are both generalised and modality-specific aspects to psychophysical sensory sensitivity, and that psychophysical task performance may reflect subjectivelyassessed sensitivity. Clinical implications of these findings will be discussed.*

## #110 - Spatial sensory organization around the body: anisotropy of audio-tactile integration

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Body-space interactions are exemplified by the distance-dependent representations of sensory inputs. The processing of multisensory stimuli is facilitated when they are located close to the body, which was demonstrated with tactile and looming auditory stimuli (Canzoneri et al. 2012). The distance of the moving sound source modulates behavioral measures in terms of tactile detection, with tactile detection becoming faster with the auditory stimulus distance to the body becoming smaller. However, little is known about the link between the functional divisions of space and the distance-dependent representations of sensory input. The present study was based on an extension of the audio-tactile paradigm described in Hobeika et al. (2020) to examine spatial sensory organization all around the body. Healthy right-handed participants had to detect as fast as possible a tactile stimulus delivered on their right hand, while hearing looming sounds coming from the four quadrants of space around the body. The auditory stimuli were burst trains of white noise that were processed through binaural rendering so that the virtual sound sources were looming toward participants from the frontal or rear hemifield and either from the left or from the right hemispace. We examined how, depending of their origin, these auditory looming stimuli interacted with the tactile stimulus' detection. Audio-tactile interactions were influenced by the portion of space from which the auditory looming stimulus came. Detection times were shorter when auditory stimuli were looming from the frontal right space, while sound coming from other portions of space elicited similar behaviors.

## #111 - The Topo-Speech sensory substitution system as a method of conveying spatial information to the blind and vision impaired

Amber Maimon 1, Iddo Wald, Meshi Ben Oz, Sophie Codron, Ophir Netzer, Benedetta Heimler, Amir Amedi

*1: Reichman University*

Humans, like most animals, integrate sensory input in the brain from different sensory modalities. Yet humans are distinct in their ability to grasp symbolic input, which is interpreted into a cognitive mental representation of the world. This representation merges with external sensory input, providing modality integration of a different sort. This study evaluates the Topo-Speech algorithm in the blind and visually impaired. The system provides spatial information about the external world by applying sensory substitution alongside symbolic representations in a manner that corresponds with the unique way our brains acquire and process information. This is done by conveying spatial information, customarily acquired through vision, through the auditory channel, in a combination of sensory (auditory) features and symbolic language (named/spoken) features. The TopoSpeech sweeps the visual scene or image and represents objects' identity by employing naming in a spoken word and simultaneously conveying the objects' location by mapping the x-axis of the visual scene or image to the time it is announced and the y-axis by mapping the location to the pitch of the voice. This proof of concept study primarily explores the practical applicability of this approach in 22 visually impaired and blind individuals. We demonstrate practically how aspects of spatial information can be transmitted through non-visual channels and weigh in on debates concerning models of spatial knowledge and the capacity for spatial representation in the blind. Finally, we present possible future developments, implementations, and use cases for the system as an aid for the blind and visually impaired.

## #112 - Neural mechanisms underlying cross-modal responses to speech sounds in the ventral visual pathway

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Learning arbitrary associations between different sensory inputs is a difficult task. Nevertheless, with intensive practice, the human brain is capable of performing the task with a high degree of precision and automaticity. One of the most impressive illustrations is reading acquisition that essentially relies on one's ability to associate speech sounds with abstract visual symbols. In literate populations, this audio-visual association learning makes a brain area in the ventral part of the occipito-temporal cortex become specialized in recognizing written scripts of known languages. Interestingly, several studies have shown that, at least in skilled readers, this area in the ventral pathway not only responds to written input but also to speech sounds. Our research team attempts to understand the neural basis of this cross-modal activation. Using neural adaptation paradigms and combining findings from different methods (TMS, fMRI, SEEG), we observed converging evidence suggesting that the over-learned and recurrent association between speech sounds and written symbols might result in a modification of the functional role as well as the neural property of some subpopulations of neurons in the ventral pathway, by making them sensitive to speech sounds despite their initial function in visual information processing.

## #113 - Inter-subject correlation unveils a shared visuo-tactile representation in primary and secondary somatosensory cortices

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Feeling a touch is different from observing a touch. However, scattered evidence indicates the presence of shared neural representations between these two sensory modalities in primary and secondary somatosensory cortices. To solve this issue, in this fMRI study, we performed inter-subject correlation (ISC) analysis between two groups of participants exposed either to a continuous tactile stimulation or a naturalistic visual movie depicting the same stimulation. Any evidence of synchronization in the somatosensory cortices across the two groups would indicate a shared representation of tactile perception (Real-Touch) and tactile observation (Visual-Touch). The Real-Touch group (N=19, F=11) underwent a continuous tactile stimulation of hands' digits or dorsum, covered from view; the Visual-Touch group (N=20, F=10) was presented with a video showing the same hand locations being stimulated with a brush. ISC analysis computed the Pearson's correlation coefficient between the BOLD activity elicited in the two groups. Statistical significance of ISC values was assessed using a non-parametric permutation test ($p<0.001$, FWEc, cluster size NN>20). ISC between individuals exposed to Real-Touch or Visual-Touch isolated brain regions responding to both tactile and visual stimulations: a significant synchronization was found in S1 and S2. Our results suggest the presence of shared neural representations between real and observed touch, identifying a multimodal representation of the hands. Crucially, primary and secondary somatosensory cortices are directly involved in this shared representation. Through an innovative methodological approach , we demonstrated a direct contribution of the somatosensory cortices in building a shared neural representation between vision and touch.

## #114 - Vection in Individuals with and without Concussion: Associations with Postural Response

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Many concussion symptoms are multisensory in nature (e.g., visual-vestibular). Commonly reported everyday situations that trigger symptoms often involve complex optic flow stimulation such as grocery shopping, which may suggest that concussions are linked with heightened susceptibility to visual motion and/or changes to multisensory integration. Vection is a phenomenon whereby dynamic visual information creates the illusion of self-motion while remaining physically stationary. The objectives of this study were to examine whether individuals with concussion are more susceptible to experiencing vection than healthy controls and whether increases in vection are associated with increased postural sway, particularly in concussed individuals. Concussed (n = 15) and control (n = 14) participants were presented with an immersive virtual grocery store scene, via a 240 field-of-view curved projection display. The scene radiated outward at different speeds to create the sensation of traveling forward down a grocery store aisle. During the task, participants stood on a forceplate and their postural sway (centre of pressure path length) was measured. At the end of each 30-second trial, they rated their perceived vection intensity. Overall, we found that concussed participants reported significantly stronger vection intensity ratings than controls. In concussed participants (not controls), greater speeds of the visual motion predicted higher vection ratings. Furthermore, higher vection intensity ratings and faster speed together predicted larger postural sway, particularly for concussed participants. Ultimately, these results provide unique insights into the extent to which concussions affect perceptual (vection) and behavioural (postural) outcomes, with potential implications for future symptom screening tools and interventions.

## #115 - Hand on Heart: a Cardiac Rubber Hand Illusion

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Body illusions such as the Rubber Hand Illusion (RHI) have highlighted how the pairing of sensations arising from the outside world, such as vision and touch, is integral to the sense of one's own body. Internally arising interoceptive sensations such as the heartbeat also provide information about the body, but it is not yet clear how they influence embodiment. In a pre-registered study, 42 participants completed a cardiac variation of the RHI, where taps to the finger occurred either in time with the heartbeat (at systole), or between heartbeats (at diastole), and either in or out of synchrony with taps delivered to a rubber hand. Participants also completed two heartbeat detection tasks to assess accuracy at perceiving interoceptive sensations. We replicated the RHI effect, showing that synchronous but not asynchronous taps to the real and rubber hand significantly increased sensations of embodiment over the rubber hand and caused a shift in the perceived hand location. However, there were no significant influences of cardiac timing on embodiment, nor did it interact with visuo-tactile synchrony. An exploratory analysis found a three-way interaction between synchrony, cardiac timing and interoceptive accuracy as measured by a heartbeat counting task, such that greater interoceptive accuracy was associated with lower embodiment ratings in the systole condition compared to diastole, but only when taps were synchronous. Although our novel methodology successfully replicated the RHI, our findings suggest that interoceptive senses may make little contribution to the sense of one's body beyond the integration of vision and touch.

## #116 - Testing geometry and 3D perception in children following vision restoring cataract-removal surgery

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*1 : Reichman University*

As neuroscience and rehabilitative techniques advance, age-old questions concerning the visual experience of those who gain sight after blindness take center stage. In this study, we employ a battery of visual perception tasks to study the unique experience of a small group of children who have undergone vision-restoring cataract removal surgery. We tested their abilities to perceive 3D using a binocular rivalry task and the Brock string task, perceive visual illusions, use cross-modal mappings between touch and vision, and spatially group based on geometric cues. We suggest that our findings present a relatively unexplored intermediate stage of 3D vision development. Importantly, we spotlight some geometrical perception visual abilities that strengthen the idea that spontaneous geometry intuitions arise independently from visual experience (and education), replicating and extending previous studies. We incorporate a new model, not previously explored, of testing children with congenital cataract removal surgeries who perform the task via vision. Our findings provide insight into the development of the visual system in the visually deprived and highlight the need to further explore an amodal, task-based interpretation of specializations in development and structure of the brain. Moreover, we propose a novel objective method, based on a simple binocular rivalry task and the Brock string task, for determining congenital (early) vs. late blindness where medical history and records are partial or lacking (e.g., as is often the case in cataract removal cases).

## #127 - Numeric and social priors modulate the sound induced flash illusion

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The sound-induced flash illusion (SIFI) constitutes one of the best studied multisensory phenomena and describes the misestimation of visual event numerosity when accompanied by a simultaneous stream of auditory events. The perception of additional illusory flashes (fission) or fused illusory flashes (fusion), induced by auditory information, has been suggested to result from the relatively larger uncertainty for temporal event estimation in the visual modality. While many factors have been identified that influence the illusion, the differential expression of fission and fusion remains elusive (Hirst et al., 2020). We tested whether this differential expression can be explained by the absolute numerosity of events included in a task. Such a modulation suggests that illusory percepts result from the combination of visual and auditory information with specific numerosity priors, such as central tendency priors. We further tested whether the effects of such priors may be modulated by social association (self vs. other) with event numerosity, suggesting that social salience can bias the SIFI via changes in pre-existing priors. Across three experiments, we found that the expression of either illusion type (fission, fusion) was dependent on absolute numerosity, suggesting that audiovisual estimates are combined with numerosity-specific priors in a reliability-weighted fashion. We further observed social modulation effects that were strongest in the illusion type that was more frequent, i.e., more strongly affected by priors. These results suggest not only that fission and fusion may result from the same underlying mechanism, but also that their differential expression follows from integration with pre-existing and novel priors.

# POSTER SESSION #3
# JUNE 29 | 12-2 PM

## #020 - When eyes beat lips: Speaker gaze affects audiovisual integration in the McGurk illusion

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Eye contact is a dynamic social signal that captures attention and plays a critical role in human communication. In particular, direct gaze often accompanies communicative acts in an ostensive function: a speaker directs her gaze towards the addressee to highlight that this message is being intentionally communicated to her. The addressee, in turn, integrates the speaker's auditory and visual speech signals (i.e., her vocal sounds and lip movements) into a unitary percept. It is an open question whether the speaker's gaze affects how the addressee integrates the speaker's multisensory speech signals. We investigated this question using the classic McGurk illusion, an illusory percept created by presenting mismatching auditory (vocal sounds) and visual information (speaker's lip movements). Specifically, we manipulated whether the speaker (a) moved his eyelids (i.e., open/closed his eyes) prior to speaking or did not show any eye motion, and (b) spoke with open or closed eyes. When the speaker's eyes moved before an utterance, and when the speaker spoke with closed eyes, the McGurk illusion was weakened (i.e., addressees reported significantly fewer illusory percepts). In line with previous research, this suggests that motion (opening or closing), as well as the closed state of the speaker's eyes, captured addressees' attention, thereby reducing the influence of the speaker's lip movements on the addressees' audiovisual integration process. Our findings reaffirm the power of speaker gaze to guide attention, showing that its dynamics can modulate low-level processes such as the integration of multisensory speech signals.

# POSTER SESSION #3
# JUNE 29 | 12-2 PM

## #117 - The multimodal Ganzfeld effect: What does it take for multimodal integration to occur?

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In the absence of dynamic sensory stimulation, the brain produces its own reality. Observing a homogenous visual field (or Ganzfeld) can induce hallucinations and altered states of consciousness due to perceptual deprivation. Multimodal GF stimuli combine homogenous visual and auditory stimulation. This study aimed to investigate alterations in consciousness and their relationship with aesthetic appreciation of such multimodal GF stimuli using a mixed-method approach, combining behavioral and neural measures with questionnaires and interviews. Here, we focus on the emergence of multimodal integration. A red GF (Exp.1, N=28) or GF with varying colors (Exp.2, N=45 ) was combined with 3 noise conditions: no, white or brown noise. Participants wore an EEG device, eyetracker and headphones, and held a dial to report hallucinations during 25-minute GF sessions. A questionnaire followed, assessing alterations in consciousness (OAV), liking, personality, etc. The results of the OAV show support for induced alterations in consciousness with significant deviations from zero for all dimensions. We found no difference in number of hallucinations between the noise conditions. The visual stimulation and visual hallucinations seemed more salient, pushing the auditory stimulation into the background. Indeed, most participants reported no auditory hallucinations, with some explicitly stating that their focus was captivated by the visuals. When auditory hallucinations were mentioned, they could occur independently of the visuals (with attention switches between modalities), or as a component of integrated audio-visual hallucinations. We will investigate these multimodal interactions further using a currently ongoing museum-based GF experiment with questions assessing multimodal integration or switching.

## #118 - Challenges in embodiment research

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We are constantly confronted with multisensory events, e.g. an approaching car can be seen and heard. If the different sensory signals originate from the same source they are integrated into one percept. Multisensory integration is also thought to elicit embodiment. For example, seeing a rubber hand touched with a brush and feeling the touch on one's own hand might give the feeling to own the rubber hand. However, some studies recently argued that embodiment could be influenced by demand characteristics, i.e. participants knowing the research hypotheses. Questionnaire items might be particularly vulnerable to such a bias. In a first study, we investigated how well participants were able to rate questionnaire items as if they had participated in a laboratory experiment they viewed on a monitor. Those ratings were highly similar to the ratings of participants who performed the actual laboratory experiment, suggesting that participants knew the research hypotheses. This demonstrates that questionnaire ratings on embodiment and related constructs (e.g. presence) can be confounded by demand characteristics. In a second longitudinal study, we investigated how participants' ratings are affected when they are repeatedly presented with the same questions. We tested this influence by repeating the same virtual reality experiment over eight sessions. Preliminary results show that embodiment ratings increased over time when avatar movements were temporally delayed, but remained unchanged if no delay was present. Altogether, this shows that different embodiment manipulations have different temporal characteristics and that demand characteristics have to be considered, especially when interpreting embodiment ratings.

## #119 - The visual word form area engages in processing Braille in expert visual readers

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In the ventral occipito-temporal cortex (vOTC) reside numerous areas specialized to identify different categories of stimuli. Among them, the visual word form area (VWFA) preferentially responds to written words. What drives this selectivity for orthographic material remains debated. One account suggests that VWFA's selectivity builds on the intrinsic selectivity for lowlevel features shared among most orthographic systems, like specific line junctions (e.g. T, L, Y). Alternatively, the VWFA could be sensitive to any alphabetic material, irrespective of these specific low-level features. We present evidence showing that VWFA, in expert visual readers, engages in processing Braille, a script developed for touch that does not share some low-level characteristic of classical alphabets like line junctions. We first show that, in expert visual Braille readers only, the region of vOTC showing preferential activity for roman-based French word over control stimuli, also showed preferential response to Braille words over control Braille stimuli. Second, we presented to the participants stimuli with four decreasing levels of linguistic properties: real words, pseudo-words, non-words, and a fake-script condition, for both Braille and roman-based alphabets. Multivariate analyses on patterns of activity from VWFA revealed that the differences between words and word-like stimuli show a dissimilarity pattern within Braille stimuli that resembles the one within roman-based French. These results indicate that typical visual features of scripts are not mandatory characteristics in the activation of VWFA for linguistic material. Rather, linguistic information itself, invariant across scripts, seems to play an important role in determining the response of this word-selective brain area.

## #120 - Localising 3D motion through the fingertips

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Our research evaluates people's ability to reproduce spatial 3D-information in motion through touch, using a novel in-house touch-motion algorithm (TMA) that translates virtual positions of moving auditory sources to four fingertips. We conducted three experiments. In the first participants were asked to reproduce motions in a 3D environment in audio and in touch separately. During the second experiments participants also underwent a multisensory audio-tactile training. Our results show that people are able to use TMA to reproduce 3D motion through touch with accuracy equal to audition. Furthermore, our findings suggest tactile performance in both experiments was slightly better than auditory when reporting start points of the moving sources and identifying horizontally static motion. In the third experiment participants experienced a complex moving auditory environment in which single sources were paired to touch. We demonstrate an immediate untrained connection, with 90% recognition accuracy of audiotactile "moving" objects within a four alternative forced choice paradigm. Questionnaires indicate most participants reported visualizing the sources while half reported the distance of the tactile/audio-tactile inputs as beyond their reach, which results point to tactile "motion" potentially inducing an extrapersonal spatial experience. We discuss learning of utterly novel sensory tasks as evidence of computation-based brain organization, and suggest our setup as carrying potential toward sensory enhancement in hearing (and visually) impaired populations, particularly cochlear implant (CI) users and unilateral hearing individuals. We have currently started another study on CI users in continuation of this research.

## #121 - Multisensory integration of speech in social context

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Speech perception requires multisensory integration (MSI) regarding auditory and visual information produced by a speaker. Although much is known about MSI of simple, well-controlled stimuli, more research is needed about MSI “in the wild”: of complex, dynamic, contextembedded stimuli. Here, we investigated gestural and visual-speech enhancement of auditory speech perception, using stimuli embedded in a social context, and therefore more ecologically valid. Participants (N=36) watched a recording of a videoconference with actors playing a (simulated) turn-taking game to name actions performed in given contexts (e.g., in a restaurant we... eat), supporting action words with gestures. Stimuli were presented under audio-visual (AV), unisensory visual (V) or auditory (A) conditions. The task was to identify the communicated action from a list of four alternatives displayed on the screen. Participants’ behavioural (accuracy and reaction times) and neuronal (EEG) data were collected. As expected, the data revealed higher accuracy and shorter reaction times in the bimodal condition than in both unimodal conditions. At the neuronal level, we observed stronger suppression in the alpha band in AV as compared to the sum of A and V. Alpha suppression had been previously linked to integration processes of visual cues in speech (lip reading and gestures). Here, we demonstrate that this effect cannot be accounted for by simple additive processing of the partial, audio and visual, information. Together, these results confirm that audiovisual speech accompanied by gestures is readily integrated to the benefit of speech perception, and extrapolate the findings to dynamic, complex, and naturalistic social situations.

## #122 - The role of conflict processing in multisensory perception: Behavioural and EEG evidence

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To form coherent multisensory perceptual representations, the brain must solve a causal inference problem: to decide if two sensory cues originated from the same event and should be combined, or if they came from different events and should be processed independently. Causal inference has been modelled using Bayesian models, where integrated (common cause) and segregated (different causes) models of the stimuli are entertained and combined to arrive to a final estimate. In the present study, we propose that causal inference involves a competition between the two possible causal models (common cause vs different causes) that engages the brain mechanisms of conflict processing. To test this hypothesis we conducted two studies, measuring RTs and EEG, using an audiovisual ventriloquist illusion paradigm with different degrees of intersensory disparities. As could be expected if the conflict mechanisms were involved in the multisensory perception of spatial location, we found slower RTs and higher fronto-medial theta power (both markers associated with conflict) for incongruent compared to congruent trials. We also predicted slower RTs and higher theta power for intermediate disparities (where there would be more competition between causal models) compared to congruent stimuli and to large disparities. Although this prediction was only significant for the RT study, given the larger variability in theta power estimations, both outcomes showed the expected trend.

## #123 - The impact of set-size in a tactile search task: Evidence from the N140cc component

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Visual search studies have demonstrated that the time needed to find a target amongst distractors can increase as a function of the number of items in the search array (i. e., setsize). While the allocation of attention in a search task has been extensively investigated and debated in the visual domain, little is known about these mechanisms in touch. Initial behavioural evidence has reported conflicting results, with some studies showing increased response times as a function of set-size, while others reporting no such modulation. In the present study, to investigate the allocation of attention to potentially relevant stimuli we measured the N140cc during a tactile search task in which the set-size of the search array was manipulated. The N140cc is a lateralized component of eventrelated brain potentials recently described as a psychophysiological marker of attention allocation in tactile search tasks. Participants had to localize the target, a singleton frequency, while ignoring one, three or five homogeneous distractors. Results showed that error rates linearly increased as a function of set size, while response times were not linearly affected. Notably, the amplitude of the N140cc decreased as the number of distractors increased. While attention was systematically directed to the target in the 2- items array, search became increasingly unguided when the set-size increased. The increasingly variable allocation of attention to different items across trials with larger setsizes resulted in overall smaller N140cc. Consistent with existing behavioural evidence, these findings highlight systematic differences between the visual and the tactile attentional systems.

## #124 - Real-time co-embodiment of a virtual avatar improves movement performance

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When a virtual avatar is controlled simultaneously by two individuals (i.e., the movement of the avatar reflects the averaged movement of them: Virtual co-embodiment), the movement performance of individuals can improve compared to when they manipulate an avatar by oneself (Hagiwara et al., 2020). In this study, we investigated whether the realtime interaction between individuals contributes to the improvement of performance under virtual co-embodiment. We compared movement performance between when individuals were co-embodied with partners in real-time and when they were co-embodied with prerecorded movements of partners. In the experiment, a pair of participants wearing HMDs and controllers were asked to reach a target in a virtual environment with a right hand of an avatar. The movements of an avatar reflected the average of two participants. We conducted three co-embodiment conditions as follows: being co-embodied with the partner's movements in real-time (realtime condition), being co-embodied with the partner's movements which recorded preliminary (pre-recorded condition), and not being co-embodied with a partner (solo condition). To examine the conscious awareness of real-timeness in being co-embodied (real-time vs. pre-recorded), we switched the instructions of the real-time and the prerecorded conditions. The results showed that the individual performances under the realtime conditions improved more (i.e., the reaching path of the individuals became straighter) than that under the pre-recorded and the solo conditions, with no effect of switching the instructions. These results suggest that individuals' movement is modulated through real-time interaction in the virtual co-embodiment, resulting in an improvement of an individual's movement performance.

## #125 - Role of visual experience in audiovisual integration in the visual cortex

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In order for cross-modal connections in the cortex to integrate information in a way that accurately represents the environment, they must be sculpted by experience. Here we addressed the question how visual experience influences audiovisual cross-modal plasticity in primary and higher order visual areas during development and how it affects restoration of vision at a later age. To address this issue, we studied the effects of darkrearing and subsequent visual experience on auditory and visual responses in visual cortical areas using chronic two-photon calcium imaging in mice. Preliminary results show that in higher order visual areas, auditory responses were more pronounced than in V1. We conclude that visual experience during development is required for refinement of audiovisual crossmodal integration and that a loss of visual experience results in more auditory integration in higher visual cortical regions than primary visual cortex.

## #126 - Haptic enhancement of speech perception in noise

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Understanding speech in the presence of noise is challenging, especially in multitalker situations. In such scenarios, research has shown that rhythmic, suprasegmental speech cues can be extracted and transmitted haptically, improving speech intelligibility. However, the extent to which haptic supplemental input derived from the amplitude modulations (i.e., temporal envelope) of speech can aid speech-in-noise perception in untrained normal-hearing listeners is not clearly defined. In the current study, 46 right-handed participants had speech recognition thresholds measured in multi-talker background noise in audio-only and audiotactile conditions. During the audio-tactile conditions, synchronous (i.e., without temporal delay) speech envelope-derived vibrotactile stimulation aligned to the speech stream of interest was presented to the palms unimanually or bimanually. The impact of the stimulation location (left, right, or both palms), audio-only speech-in-noise ability, and tactile sensitivity, as measured using vibrotactile detection thresholds, was also evaluated. Results indicate that speech envelope-based haptic stimulation can enhance intelligibility in noise. Critically, this effect emerged even in normal-hearing listeners and without training, which is suggestive of the propensity of audio-tactile associations during speech. As per our findings, the choice of stimulation location is not a significant factor contributing to this audio-tactile speech enhancement, but speech-in-noise ability in audio-only conditions and vibrotactile sensitivity play a role in its extent. Taken together, our results illustrate the critical role of perceiving speech rhythmic cues in a multi-talker setting, and particularly the amplitude modulations of the speech stream of interest, independently of the sensory modality.

## #128 - Anistoropy of audiotactile peripersonal space between rear and front space

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Peripersonal space (PPS), which refers to the space immediately around the body, plays an important role in interacting with external objects and avoiding potential threats. The auditory system can hear sounds from various directions, including those outside the field of view (FoV), and can assist in detecting potential threats from outside the FoV. However, it is still unclear whether there is a difference in audio-tactile PPS between stimuli coming from inside and outside the FoV. This study aims to compare the audiotactile PPS in the front (i.e, inside the FoV) and rear (i.e., outside the FoV) space. To measure the audiotactile PPS, we presented the tactile stimulus while the task-irrelevant auditory stimulus was looming toward the listener. The listeners were instructed to press a button as soon as when they detected the tactile stimuli delivered to their chest. The results showed that the auditory facilitation effect was more pronounced in the rear than in the front condition. Based on these findings, it can be inferred that the audio-tactile PPS is larger in the rear than in the front space.

## #129 - Brain mechanisms of Odor-Induced Taste Enhancement in people living with normal-weight or obesity

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Flavor perception necessitates the integration of at least odor and taste from the food. As a consequence, some odors acquire the property of enhancing the taste perception. This phenomenon, called odor-induced taste enhancement (OITE), has been shown in one study for sweet OITE to be higher in people with obesity (OB) compared to normalweight (NW). Although, the brain structures involved in flavor have already been identified, the organisation of the network is still unknown. We first studied the effect of weight gain (obesity) on the perception of OITE in a sensory study. 17 sweet and salty drinks were used to investigate the perceptual variability of OITE between the two populations. Our results showed that OITE is higher in some solution in OB than in NW. Moreover, some OITE were population-specific, which points towards a different exposure to the tested flavors related to diets. In a second study, the brain organization (EEG) of OITE was studied in both populations in 4 sweet and salty solutions. The results confirmed partly the integration of odor and taste in high-level brain structures in both groups. In people with obesity, the late processing of the flavor was lower.

## #130 - Effects of dynamic alterations of depth cues during continuous dynamic interaction

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Depth perception results from the integration of different visual cues. Texture and disparity contribute in different degree to the perception of 3D orientation of surface, according to a weighting mechanism, usually studied under static conditions. We wonder what happens in dynamic situations, especially what happens when one subject interacts with a cue while the other remains fixed. Is that a bias on the perception? With the goal of investigating how interaction modulates perceptual processing, we developed a novel approach for delivering visual stimulation that could overcome the limit of traditional passive visualization. By leveraging graphic engines (e.g., Unity) and VR potentialities, we design dynamic and complex visual stimulations in a straightforward approach. Changes in selected perceptual parameters are contingent on subject's actions. In the experiment the subject viewed 3D oriented planar surfaces through a circular aperture. The surfaces were characterized by conflictual depth cues (disparity and texture) both in slant and tilt. The subject could bimanually interact with a wooden tablet, with one cue while the other remained fixed. The subject must continuously rotate the board in order to align the perceived direction of depth gradient along diametrically opposing target tilts. We observed a systematic effect of the fixed cue on the subject motor behavior which suggests a contingent change of the perceived 3D orientation. We hypothesize that this effect could be due to a dynamic weighting of depth cues and that the proposed approach could contribute to a better understanding of how a dynamic interaction affects perceptual integration processes.

## #131 - Brain encoding of continuous touch

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Studies employing EEG to measure somatosensory responses have been typically optimized to compute event-related potentials in response to discrete events (ERPs). However, tactile interactions involve continuous processing of non-stationary inputs that change in location and dynamic. To fill this gap, this study aims to demonstrate the possibility of measuring the neural tracking of continuous and unpredictable tactile information. Twenty-seven young adults (F=15) were continuously stimulated with a random series of gentle brushes on single fingers of each hand, which were covered from view. Critically, tactile stimulation was unique and differed across fingers and participants. An encoding model measured the degree of synchronization between brain activity and continuous tactile input. We contrasted the neural tracking of finger stimulations versus a control condition in which the experimenter's hand, covered from view, was stimulated instead of the participant one (thus controlling for spurious auditory and visual confounds, e.g., the sound of the brush or rhythmic movements of the experimenter). Brain topographies of the encoding of continuous stimulations to each finger showed a contralateral response peaking at about 140ms of lag followed by a bilateral response at about 240ms. No reliable encoding was measured with the control condition. Our results demonstrated for the first time the possibility of using EEG to measure the neural tracking of an ecological, unpredictable, and continuous stimulation in the somatosensory domain. Crucially, this approach allows linking brain activity with individualized, idiosyncratic stimulations. This approach has the potential to push forward real-world studies involving also bodily senses.

## #132 - Natural language representation of spatial relations in haptics

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Haptics is a perceptual domain that significantly contributes to the spatial knowledge and representation. However, spatial perception through haptics and its links with other senses and higher mental processes have not studied much. In our study, we test the topological relations (according to Region Connection Calculus, Randell et al, 1992) and several geometrical features (e.g., orientation, distance) as perceived through haptics and further transformed into the natural language representation. We apply two widely accepted frameworks of spatial cognition in visual perception. First, for exact location of the object (Figure), a reference object (Ground) must be involved (Talmy, 1975), and, second, the perceived fine-grained and metric spatial relations are mainly transformed into categorical ones when represented linguistically (Newcombe & Huttenlocher, 2000). We use experimental stimuli (generated for haptic scanning) that contain two different circles (1x1 cm) located in various spatial configurations (n=14). In a production task participants (n=38) are asked to answer where is located the marked circle in respect to the other non-marked circle. We have conducted similar experiments with visual stimuli (Šķilters et al., 2020). The results show the use of the same categories in both settings, however, the frequencies and impact of geometric and topological factors differ significantly in visual and haptic spaces.

## #133 - Looks Like It Smells Good: A Multimodal ERSP Study Using Wood Odour And Images

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Studies have shown that wood odours are pleasant and relaxing. Additionally, congruent odours and context (e.g. visual) are perceived as more pleasant, and incongruency disrupts pleasantness. Generally, the perception of odour produces early increases in theta band power in EEG and later decreases in alpha band power, especially at midline electrodes. For congruency, sparse literature led us to expect an interaction effect at midline electrodes. In this study, we presented pine wood odour or clean air with congruent or incongruent images to 21 participants, resulting in a 2x2 factor structure. We analysed pleasantness ratings and Event-Related Spectral Perturbations (ERSP) in response to the combinations. We found that wood odour alone was not perceived as more pleasant than air, but that combined with congruent images it was rated as most pleasant. Additionally, the trials of wood images alone caused higher pleasantness ratings. It was surprising that vision dominated, and wood images even caused air to be perceived as more pleasant. However, the interaction confirmed our expectations that congruent stimulation of the olfactory and visual senses enhances pleasantness: the sum being greater than its parts. In response to the wood odour, preliminary ERSP results at electrodes Fz, FCz, Cz, CPz, and Pz showed an early-starting and long-lasting power increase in the delta band and a simultaneous decrease in alpha band power. Electrodes Fz, FCz, and POz also showed a later and shorter delta band power change for the interaction. Overall, results show how multisensory integration between odour and vision takes place.

## #134 - Modality-specific time scales reflect modality-specific brain oscillations

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Prominent theories of brain function argue that oscillations are critical for representing sensory information. However, different sensory modalities are associated with different frequency bands and band-specific functional properties. For example, the dominant visual rhythm, alpha, seems to operate via inhibition, whereas the somatosensory rhythm, beta, has been described as operating through a different, and sometimes excitatory, mechanism (Buchholz et al., FHNeurosci, 2014; Baumgarten et al., PNAS, 2015; Keil et al., MultisensRes, 2017). At the same time, it has been suggested that if oscillations perform a function in representation, then such a function should operate across sensory modalities (e.g., White, ConsciousCogn, 2018). One way to reconcile this seeming contradiction involves a principle operating across modalities and a broad range of frequencies, in which oscillations provide conditions for representation. Oscillatory transitions, in general, might offer temporal windows for representational activity to manifest. If so, the rate at which discrete representations can form should map onto the relative prevalence of oscillatory activity, and different modality-specific oscillatory compositions should reflect different sensory time scales. We tested this, and related hypotheses, in a preregistered study (https://osf.io/cgj38/) combining magnetoencephalography and psychophysical tasks designed to track rates of perceptual representation over touch, vision, and audition (Fig.A-B). Over three replications we found that modality-specific oscillations correlated with modality-specific capacity to form discrete representations (Fig.C-D). This suggests that a general function of oscillations is to offer windows for perceptual representations to emerge, and different sensory time scales reflect differences in oscillatory composition.

## #135 - Distorted reality? Exploring visual and haptic feedback in body representation

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We gain an understanding about the size and shape of our bodies (body representation) through various sensory modalities (e.g., vision, haptics, audition). Healthy adults display systematic distortions in hand representation measured by implicit (no overt judgement of hand size), but not explicit tasks. Most implicit paradigms rely on haptics, and explicit tasks on vision, therefore, the distortions may be haptically driven. We designed an implicit paradigm to measure both visual and haptic body representations. We hypothesized that if body representation distortions are due to haptics, then participants should have more accurate visual body representations. As target body parts we chose the hands (consistent with previous studies on implicit body representation), the feet (anatomically like the hand), and the waist (emotionally charged area). On each trial a different sized clothing item (gloves, shoes, and belts) was presented on a tabletop. The participant visually or haptically judged if the item was bigger (2AFC method) than their body part. We calculated the point of subjective equality (PSE) and standard deviation (SD) for each item in both conditions. PSE refers to the value at which the participant judged the clothing item as being equal to their body part (implicit body representation) and SD is the precision used in that evaluation. Preliminary results show PSE biases (compared to physical body size) in both sensory conditions. However, the haptic condition produced significantly larger biases than the visual condition, particularly when estimating hand size. These results support the suggestion that haptics is driving implicit body representation distortions.

## #136 - The tactile perception of uppercase, lowercase and manuscript letters in children and adults

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Reading acquisition is inherently a multimodal learning process, requiring an audio-visual mapping between the sounds of language and visual letters. We have proposed a multimodal synergy hypothesis where multiple representations of letters in different systems could facilitate the visual recognition of ambiguous letters (Pegado et al., Frontiers 2014). We have probed this hypothesis by showing that multimodal training improves visual recognition, writing and reading fluency in 1st graders (Torres et al., Current Biology 2021). We now ask whether tactile perception of letters could contribute to such “multisensory mental model of letters”. Surprisingly, it is currently unclear what type of letter format (uppercase, lowercase or manuscript) in Latin alphabet is the most suitable for tactile perception. Here, we made this characterization in both 2 nd graders children (n = 15) and literate adults (n = 24). We found good spontaneous tactile recognition without any training: out of the 26 letters (M= 19.58) in adults and (M = 10.58) in children. In both groups a higher recognition rate was found for uppercase > lowercase > manuscript letters. Importantly, analysis of specific letters shows extreme variations in recognition rate (ranging from ~25 to 100% in each format in adults). Interestingly, ambiguous letters for the visual system (mirror-letters such as p-q) are easily recognized in the tactile system. These results show that the tactile system can convey information about some but not all letters and suggest its potential as a complementary source of information in early stages of literacy acquisition, specially targeting visually ambiguous mirror-letters.

## #137 - Draw Your Scotoma: Sensory-motor task as a New Screening Tool

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Scotoma is an area of partial or complete alteration of the visual field encircled by preserved visual capabilities. Nevertheless, binocular vision often compensates for scotoma until it is impossible to compensate. Early-stage/monocular detection and mapping are critical for the diagnosis and possible treatments. Medical experts have detected the disease; further research is needed for easy-to-access detection methods. Here, we develop a new method to quickly detect and map the scotoma. Previous research has shown that patients tend to avoid the scotoma area when they perform spatial tasks. For this reason, we developed a "drawing task" to develop a method for easy detention of scotoma location. Participants were presented with three white targets on a touch screen, and their task was to pick up one of the three targets by drawing lines with their fingers. It disappeared whenever they caught the target and others appeared in other locations. The 3 targets were located so that one of the targets always appeared behind the scotoma. The input painted on the screen in the background was not visible to participants. The hypothesis is that participants will tend to avoid the target near the scotoma, leaving that part of the screen blank. Sighted participants were tested twice, with or without a fake scotoma. Our preliminary results showed that the area behind the scotoma is less likely to be reached and discovered. The avoidance was strongly observed for the movement that requires passing through the scotoma.

## #138 - Theta-band activity is modulated by errors during online movement control

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To ensure optimal visuomotor feedback control, the brain must continuously monitor the error between the hand and the target. It is well documented that modulations in mediofrontal theta-band [4-8 Hz] activity are related to error processing, but mostly in cognitive control contexts. Hence, it remains unclear whether theta oscillations are also modulated by hand-target errors during online movement control. The objective of this study was to test this hypothesis. Electroencephalography (EEG) was recorded in 29 healthy adult participants while they tracked a moving target with their right hand. Two conditions were used to manipulate the demands for error processing. In the repeated condition, the same target trajectory was presented 80 times, inducing low tracking errors. In the random condition, 80 different trajectories were used, inducing high tracking errors. Behavioral analyses confirmed the significantly higher tracking errors in the random condition. Interestingly, in line with the hypothesis, EEG results revealed that theta power was also significantly higher in the random condition, with a peak difference occurring at electrodes overlaying the left sensorimotor regions. This effect was selective to theta activity, as there was no modulation in alpha- (8-12 Hz) and beta-band (15-30 Hz) activity. Overall, this study extends current knowledge of the role of theta oscillations for error processing to the context of motor control. These modulations could reflect cortical activity mediating the communication and integration of information within sensorimotor circuits including the motor, premotor and parietal cortex, all of which are known to mediate online movement control.

## #139- Domain-specific cortical organization of multisensory processing

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The cortical activity associated with multisensory functions is adaptive to contextual factors, including representation domains such as space and time. The present work discusses the domain-specific organization of multisensory processing at the cortical level. First, we measured the ERP responses of healthy adults during spatial and temporal bisection tasks, in which audiovisual stimuli were identical between the two tasks, which differed only in the experimental question. In a 50-90 ms time window poststimulus, participants showed greater activation of the occipital areas during the spatial bisection while stronger responses of the temporal regions during the temporal bisection. Overall, we showed a cortical modulation of sensory areas that depended on the domain of representation of the multisensory processing (domain-specificity). Secondly, we investigated whether the kind of spatial request underlying multisensory stimuli also influenced the domain-specificity of occipital areas. We compared cortical activation between a spatial bisection and a spatial localization task. Results showed that the spatial bisection was accompanied by a more pronounced early occipital component (50-90 ms), whereas the spatial localization was associated with a stronger later occipital response (110-160 ms). Thus, the neural modulation of occipital areas depended also on the kind of spatial task involved in the multisensory processing. To conclude, these studies reveal that multisensory functions at the cortical level are not fixed but are modulated by the representation domain and the kind of layout of the multisensory phenomena.

## #140 - Cross-modal vision-to-touch 'translations': challenges and insights from materials science, psychophysics, and synesthesia

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While there has been extensive research into multisensory visual and auditory perception, other senses have received relatively little attention. This project focuses on the perception of touch in a multisensory context. Specifically, we explore how particular physical properties of surfaces are perceived during haptic exploration, and which visual experiences such exploration may evoke. The first challenge we face is creating surfaces with exact physical properties; there is not yet a touch equivalent of a TV or loudspeaker. We use the tools of nanoengineering and materials science to create surfaces that vary precisely (e.g., in terms of J/m^2 of adhesion) and orthogonally (e.g., altering adhesion while keeping roughness constant). The second challenge is to establish a relationship between physical properties of materials (such as "adhesion") and perceptual properties of touch (such as "stickiness"). We conduct psychophysical experiments using custom-made materials from the Lipomi Research Group. The third challenge is to create an appropriate "translation" between perceptual properties of vision and touch: what links exist between the perceptual dimensions of vision (e.g., hue) and touch (e.g., roughness)? We employ an extraordinary condition called touchcolor synesthesia to reveal naturally occurring associations between perceptual properties of touch and vision (for example, "rougher surfaces may elicit yellower colors"). We can then use this knowledge in reverse: given a target color, we can determine which touch sensation is likeliest to elicit it, and which material properties are likeliest to elicit that touch sensation. This approach represents a plausible strategy for creating vision-totouch sensory substitution devices.

## #141 - The audio-tactile somatic rubber hand illusion in sighted and blind children

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The Somatic Rubber Hand Illusion (SRHI) is an ideal paradigm to study how non-visual sensory information in spatial proximity to one's body can modulate one's perceived position. In the tactile SRHI, a blindfolded participant is guided in brushing a dummy hand while the experimenter synchronously brushes the participant's hand; this can induce proprioceptive drift, i.e., a shift in the perceived position of one's own hand. This effect has been broadly documented in sighted adults and children and is known to be enhanced with auditory cues in adults (audio-tactile SRHI). Blind adults, however, seem immune to tactile SRHI. The present study aimed to investigate the development of SRHI -both tactile only and audio-tactile- in sighted and blind children (sighted, n=51; blind, n=14; 6-11 yrs). The tactile condition was similar to previous studies exploring SRHI (as described above); in the audio-tactile condition, a sound (white noise) was presented in phase with the brushstrokes. In both conditions, sighted children showed significant proprioceptive drift, increasing as a function of age. The audio-tactile condition did not enhance the SRHI effect. In line with previous studies on blind adults, blind children were immune to both tactile and audio-tactile SRHI, and proprioceptive drift was significantly larger in the sighted group in both conditions. Our results suggest that visual experience is necessary during development to integrate contextual sensory information (tactile and audio-tactile) into one's position sense and to ultimately develop a flexible representation of one's body in space.

## #142- The visual and auditory impact of face masks on the reconstruction of speech features

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In this study, we investigated to what extent face masks impair the neural processing of visual and auditory signals of continuous speech. While the EEG was recorded, participants (30 adults, mean age: 27.7y) were exposed to continuous audio-visual speech embedded in babble noise in three conditions: Un-Mask (full AV input), Virtual-Mask (the mouth was occluded, but the audio was intact) and Real-Mask (the mouth was occluded, and the audio degraded by the presence of the mask). We measured the neural tracking of sound-envelope and lip-movements through backward modeling, and thus, these speech features were reconstructed from the corresponding neural response. Results revealed that face masks act as visual and auditory filters for the neural tracking of speech signals. As expected, the occlusion of the mouth abolished neural tracking of lip information. Most importantly, we observed that speech-envelope reconstruction was greater in the absence of auditory and visual obstacles (Un-Mask), was degraded in the case of a visual filter (Virtual-Mask), and was even more hampered in the presence of an audio-visual filter (Real-Mask). Specifically, occlusion of the mouth impacted neural tracking of speech envelope at earliest time-lags suggesting a detrimental effect on the ability to predict and integrate AV speech. The physical filter determined by the Real-Mask had a long-lasting impact on the neural tracking of speech, indicating detrimental impacts at multiple stages of auditory processing. These results highlight the contextual effects of impoverished sensory information on the reconstruction of audio and visual speech features and their multisensory integration.

## #143 - Neural tracking of continuous speech envelope in cochlear-implanted children

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Cochlear implants (CI) can partially restore hearing. Since implantations typically do not occur before 9-12 months of age, in the case of congenital deafness, children experience a significant delay in spoken language exposure. Yet, how do auditory cortices process natural speech in people with CI is unknown. To fill this gap, we studied CI children with congenital deafness or delayed deafness onset and assessed the impact of perinatal auditory deprivation on the development of speech neural tracking. We used an encoding model to measure how speech envelope is encoded in the brain of hearing control children (HC; N=37) and in two groups of CI children, congenitally deaf (CD; N=16) and delayed deaf (DD; N=16). Results clearly revealed a delay of speech envelope tracking in children with CIs compared to HC ($p<0.001$). No difference emerged between CD and DD groups. Multivariate encoding of the spectrogram revealed that the low-frequency range drove delayed envelope tracking. Finally, the delay was mitigated in the case of early implantation ($p=0.016$). Results unveiled that neural tracking of continuous speech develops in CI children, but its dynamic is altered. The lack of difference between CD and DD indicates that neural tracking of speech envelope emerges regardless of the presence or absence of acoustic experience in the first phase of life. These results pave the way for multimodal assessments of natural speech tracking in children with atypical auditory development.

## #144- Assessing the contribution of visual speech features to audiovisual speech perception in noise

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Seeing the face of a speaker improves their intelligibility - particularly when noise obscures the speech signal. Listeners predominantly direct their gaze toward a speaker's lips which is not surprising since the lips convey general dynamic information that is correlated with the acoustic envelope and detailed articulatory shapes which convey complementary linguistic information. Neuroimaging work has also found an enhancement of lip processing regions in visual cortex when the acoustics are missing. Together, this suggests that the lips are an important feature of visual speech which the brain exploits to assist speech processing. Yet it remains unclear whether the information that confers the improved intelligibility of noisy audiovisual speech is derived from the correlated lip dynamics or the complementary lip shape. Here we present an experiment where we have modulated the amount of facial information available to listeners as they listen to audiovisual speech in noise (-9 dB). In particular, we have tested the effects of degrading the information available from the lips on speech comprehension - while the rest of the facial information remains intact. Although both types of visual speech cues are important, our results show that the behavioral benefits of visual speech depend especially on access to the complementary articulatory information. These results extend our understanding of the contribution of visual linguistic features to audiovisual speech perception.

## #145 - Characterising Age-Related Impacts on Multisensory Decision-Making Processes: A Hierarchical Drift Diffusion Model Analysis

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Multisensory decision-making is associated with diverse changes through natural ageing. However, a mechanistic insight into age-related impacts on its underlying cognitive processes remains unclear. Here, we sought to investigate age-related impacts on the behavioural indices of multisensory decision-making. We employed an online variant of a well-established object categorisation paradigm to assess how complementary audiovisual information benefits perceptual decision formation, compared to visual or auditory information alone, between younger adults (aged 18-40) and older adults (aged 40+). We characterised age-related impacts on the latent processes underlying perceptual decision formation by fitting participants' single-trial RTs and binary responses to a Hierarchical Drift Diffusion Model (HDDM). The HDDM demonstrated parsimonious fits for characterising the discrepancies in RTs and choice accuracy between younger and older adults. We observed slower sensory evidence accumulation (i.e., drift rates) for older adults across all three sensory conditions. In harder trials (i.e., decreased stimulus salience) we observed 1) increases in response caution (i.e., decision boundaries) and 2) decreases in the duration of non-decisional processes (i.e., non-decision times) for older adults when categorising audiovisual versus visual information. Our findings suggest that older adults trade-off multisensory decision-making speed for accuracy to preserve enhancements towards perceptual decision formation relative to younger adults. Hence, they display an increased reliance on integrating multimodal information, through the principle of inverse effectiveness, as a compensatory mechanism for a generalised cognitive slowing when processing unisensory information. Overall, our findings demonstrate how computational modelling can reconcile contrasting hypotheses of age-related changes in processes underlying multisensory decision-making behaviour.

## #146 - The effect of visual mouth cues on neural tracking of speech in 10-month-old infants

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In this study, we investigated whether visual speech cues, such as mouth movements, facilitate neural tracking of speech in infants. EEG was recorded for 63 10-month-old Dutch-learning infants, while they watched videos of a native Dutch speaker reciting passages in infant-directed speech. Videos either displayed the full face of the speaker (Audiovisual [AV] condition), or the speaker's mouth and jaw were masked with a static block, obstructing the visual speech cues (Block condition). To assess neural tracking, speech-brain coherence was calculated, focusing in particular at the stress and syllable rates (1-1.75 and 2.5-3.5 Hz respectively in our stimuli). To investigate whether infants show neural tracking of speech, cluster-based permutation analyses were performed by comparing real speech-brain coherence to surrogate data, created by randomly pairing the speech envelope with the EEG data. Then, differences in infants' speech-brain coherence in the AV and Block conditions were tested with cluster-based permutation at the frequencies of interest. Our preliminary results (N = 18) indicate that infants show robust neural tracking at both the stress and syllable rates at all electrode sites (cluster p's = .002). However, we identified no differences between the fully audiovisual vs. blocked conditions, meaning that infants showed speech-brain coherence in both conditions, and likely tracked the speech signal equally well when visual speech cues were present or masked (p's > .05). Thus, infants' speech perception is not necessarily impaired when visual speech cues are not fully visible, such as when they are listening to a speaker wearing a facemask.

## #147 - Exploring multisensory integration of non-naturalistic sounds and eating disorders symptomatology on body perception in young females: preliminary findings

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Individuals with subthreshold Eating Disorder (ED) symptomatology and anorexia nervosa experience difficulties in integrating auditory-signals related to body weight into their body perception. However, it is unclear whether these impairments are specific to auditory bodily signals or extend to any auditory signals. We used the "auditory Pinocchio illusion", where the perception of finger length changes when a rising pitch is paired with a pulling action. We recruited 63 young female participants and assessed their ED symptomatology. Participants pulled their index fingertip (Experiment 1) or the sides of their waist (Experiment 2) while hearing brief sounds of rising, falling, or constant pitches. We examined the strength of both illusions using estimations of body part position/size and questionnaires. Results showed that participants estimated their finger to be longer and reported feeling their finger rising and stretching with the rising pitch, whereas their finger felt shorter and squashed with the descending pitch. Greater ED symptomatology was associated with greater illusions of finger elongation, shortening, and rising. In the waist illusion, participants felt their waist wider with the rising pitch and narrower with the descending pitch. Our study is the first to show that changes in the perception of body size can be induced with non-naturalistic sound paired with a horizontal movement, while also showing perceptual resizing effects on a body part emotionally significant for people with ED (waist). These findings contribute to our understanding of the mechanisms underlying body perception and may have implications for novel clinical interventions targeting people with EDs.

## #148 - Comparing the absolute and relative Simon effects in vision and touch

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Existing evidence suggests that the stimulus location is automatically encoded even when it is completely task irrelevant. Both visual and tactile stimuli facilitate the ipsilateral response when presented on the left or right side of space or of the body (absolute or trunk-centred Simon effect, respectively). However, when more than one stimulus is presented within the same side of the space (or the body) a relative spatial code also emerges, giving rise to the relative or hand/centred Simon effect. Thus far this multiple spatial codes created by visual and tactile stimuli have been investigated under very different experimental conditions. The aim of this study was to directly compare the properties of the spatial codes activated by visual and tactile stimuli in a comparable task. On different blocks of trials, participants responded to the frequency (high/low) of a tactile or visual stimulus using the pedals (right/left) to respond. The stimulus could appear in one of four possible locations, closely matched between visual and tactile stimuli. In touch we observed both a trunk-centred and a hand-centred spatial code, in line with existing results. Surprisingly, no Simon effect emerged in vision. Responses were slower for lateral compared to central stimuli regardless of response location. These results suggest that spatial coding in vision may depend on the type of task relevant stimulus feature.

## #149 - Multisensory integration in depth: a virtual reality feasibility study

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In the study of multisensory perception simple experimental protocols and elementary stimuli (i.e., beep and flash) are typically used, which are not able to capture the complexity of a natural environment. Researchers have recently started to study such processes in more ecological conditions (e.g., investigating distance-modulation effects), though the used protocols are still limited. Indeed, stimuli are conveyed uniquely within limited static locations in space with limited or no interactivity. In such context, Virtual Reality (VR) and spatial audio technologies pose an opportunity to investigate crossmodal interactions processes in more realistic, and interactive scenarios, while maintaining the control on the stimuli. In order to evaluate the usability of cross-modal virtual reality platform for multisensory studies, we tested the feasibility of a simultaneity judgment task between audio-visual stimuli with various stimulus onset asynchronies, in both close and far locations, as in Van Der Stoep et al., Exp. Brain Res., 2018. Specifically, stimuli were presented in three frontal directions in the horizontal plane: three azimuthal orientations (0°, 26° and -26°). For each orientation, the audiovisual stimuli (always spatially aligned) were presented near (0.80m) or far (1.60m) to the observer. The platform consists of VR Headset in combination with a pair of headphones. The preliminary obtained outcomes shown larger temporal acuity in audio-lead condition than visuo-lead condition and not differ significantly in near vs far locations.

## #150 - Auditory and body perception in microgravity

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IThere is an association between altered body ownership/embodiment and dysfunctional vestibular processing. Here, we tested whether the temporary modification of vestibular information linked to gravity is enough to induce modifications in the head-centered frame of reference used to localize sounds in space, and subjective distortions in body representation. Two groups of healthy human participants were asked to indicate the lateralization of auditory sources in different sensory conditions linked to gravity (1G and 0G) and vision (eyes opened and eyes closed). The Flying group (N=12) did the experiment during parabolic flights and the Control group (N=35) did the whole protocol in normogravity. In the eyes opened condition, we manipulated visual perspective, by providing participants with an image of their body as if they would see themselves from an “out-of body” location, i.e. without the apparent left/right reversal inherent to a mirror image. Modifications of localization of the self and distortions in body perception were studied through pre-and post-experiment questionnaires. The percentage of correct responses in the auditory localization task significantly differed according to the gravity and visual condition in the Flying group, as well as the scores of the questionnaires pre- and post-experiment. No significant differences were observed in the Control group across the protocol. The results suggest that the lack of position information from graviceptors is enough to induce distortions in the anchorage of perception that might be the key to bodily illusions. These distortions do not require time for their induction, as previously suggested in normal gravity conditions.

## #151 - Multisensory Category Learning of Shapes and Sounds

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The ability to form object categories facilitates the recognition of objects in our environment. However, it is unclear to what extent exposure to multisensory versus unisensory information influences the categorisation process. Here, participants conducted an online study in which they learned to categorise eight visual, auditory and audio-visual stimuli into one of two categories (“A” and “B”; i.e., four stimuli per category). Visual stimuli were two-dimensional, geometric shapes, each 10 degrees apart on a validated circular shape space (Li et al. 2020; J. Exp. Psychol., 149, 949). Auditory stimuli were shape-based soundscapes (i.e., visual shapes converted to sounds). Audio-visual stimuli were visual shapes paired with a matching soundscape. The unimodal visual, auditory and bimodal conditions comprised a different, randomised stimulus set presented in random order blocks. To assess if categorisation ability generalised beyond the learned exemplars, the participants categorised the eight learned stimuli plus four novel stimuli, extracted from the middle and outer edge of each category (i.e., two novel stimuli per category). Initial results indicated categorical learning occurred in all modality conditions. Accuracy in categorising novel compared to learned stimuli was not influenced by modality condition. However, the participants were, overall, less accurate at differentiating stimuli based only on auditory information, suggesting a greater dependency on the visual modality for category learning and discrimination.

## #152 - Interplay of somatosensory and motor inputs in teleoperated self-touch

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Touching one's own skin is special in that it provides time-locked contingent tactile, proprioceptive and motor inputs. It is also unique in that we get simultaneous tactile inputs from two skin surfaces (i.e., double touch). What is the interplay between these simultaneous tactile, proprioceptive and motor inputs? Cataldo et al. (2021, 2022) decoupled these types of inputs to study their mutual roles. They asked participants to evaluate the extent of either movement or of touch. They showed that when evaluating only one of them, the other, task-unrelated inputs affect participants’ perception of magnitude, differently for passive and active movements. Our aim is to replicate and extend their findings by adding a condition with unconstrained active motion; thus, compared to their study, our participants decide not only when to initiate an arm movement but also how to move and when to stop. Preliminary results of a pilot experiment indicate an interference of the movement of the right hand with the perception of a tactile extent on the left arm. They also show that the perception of the movement extent seems to be influenced by the task-unrelated tactile stimulation. We will run a full scale experiment before the conference to better understand these interactions. These findings are relevant to the question of how infants learn about their body. We speculate that the rich self-touch contingency acts as a scaffold for infants to learn their body's spatial properties such as its topology, configuration, or constraints, and also helps them develop their peripersonal space.

## #153 - Neurocomputational characterisation of differences in multisensory processing in Autism and Schizophrenia

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Complementary cues from different sensory modalities are combined in the human brain to yield behavioural estimates, a process known as multisensory integration. This process may be impaired in individuals with mental and developmental disorders. In this study, we investigated the neural processes underpinning multisensory integration in the brains of individuals with Autism Spectrum Disorder (ASD) and Schizophrenia (SZ) in comparison to neurotypical (control, CN) individuals. To address this question, 32 CN, 23 ASD and 35 SZ individuals undertook an audio-visual (AV) synchronous detection task. Participants were instructed to respond as quickly as possible to an Auditory (A), Visual (V), Audiovisual (AV) or no (catch –C) cue while their electroencephalograms (EEG) were recorded. Generalised linear mixed effect modelling showed an effect of both sensory modality and population on reaction times (RTs). Single-trial linear discriminant analysis (LDA) contrasting the EEG signals of the four conditions identified the neural representations of the uni- and multi-sensory cues and their differences between a) groups and b) individuals who showed multisensory gain (shorter multisensory RTs than predicted by the race model, MSI+) and those who did not (MSI-). We found robust early sensory and post-sensory EEG components of uni-sensory and multi-sensory representations with consistent timings but different reliability across the three groups. We also quantified significant differences in the discrimination power of these components between MSI+ and MSI- individuals. This research sheds light on the neural mechanisms of multisensory integration and can contribute to the development of sensory-enhancing technologies to provide an inclusive future.

## #154- Top-down and bottom-up attention in a multiple object tracking task

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Previous behavioural studies have shown that the addition of sensory cues in a multiple object tracking environment can allow adults to track a higher number of multiple moving target objects amongst similar indistinguishable distractor objects compared to when no cues are presented (Föcker et al., 2022). The aim of the experiment was to investigate whether the collision of objects against an inner circle which caused a sensory cue (auditory, visual, and audio-visual) to be elicited compared to an object collision that elicited no cues can guide attention in a bottom-up or top-down mechanism during tracking multiple moving target objects. Sensory cues were either presented on target objects or on distractors. We predicted that when the cues were placed on distractor objects, it would impair tracking performance as attention would be automatically guided towards the elicited cues. Thirty-three participants (age: M= 20 years, S.D= 1.3; 16 Female, 1 Non-Binary) were asked to keep track of target objects amongst similarly indistinguishable distractors, only the position of the cue changed from target to distractor. The results showed that visual cues presented on target objects improved attentional tracking capacity, whereas tracking performance was impaired when the visual cues were presented on the distractor objects. Distractor effects were not shown in the visual cue absent condition. Tracking performance was better when auditory cues were absent compared to present. Therefore, visual cues guide attention in a top-down mechanism when they are placed on target objects but impair this mechanism when placed on distractor objects.

## #155 - Exploring the neural basis of phonemic representations from sounds and vision

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Speech is a multisensory signal that we can decipher from the voice and/or the lips. If the successive computational steps necessary to transform the auditory signal into meaningful language representations have been extensively explored, little is known on how the visual input of speech is processed in the brain; and how auditory and visual speech information are combined to converge onto a unified linguistic percept. In this study, we aim to identify brain regions that are involved in auditory (phonemes) and visual (visemes) phonology and explore whether some brain regions can be considered as multisensory abstract phonological regions supporting both auditory and visual phonological representations. We rely on functional magnetic resonance imaging (fMRI) in healthy adults to classify brain activity patterns evoked by phonemes and visemes. Preliminary results suggest that a network of visual, motor, auditory and frontal regions are involved in viseme recognition. Interestingly, auditorily defined phonological regions (in superior temporal gyrus - STG) seem to be involved in visual phonological representations as well. Moreover, overlap between auditory and visual decoding in mid- and posterior STG and in motor cortex indicate that these regions could be involved in the integration of auditory and visual speech phonology.

## #156 - Crossmodal identification of sound gestures by untrained listeners

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Communication through auditory cues often evokes associations to other sensory modalities. In film music, for instance, a descending pitch contour commonly resembles a falling motion. In music theory, such crossmodal metaphors to physical actions or shapes have been termed 'sound gestures'. Little is known about how reliably listeners perceive such gestures and how salient the gesture-relevant auditory feature needs to be. We report on an exploratory study concerning the identification of sound gestures by crossmodal matching using analogous visualised gestures. The study considered gesture-related factors such as auditory salience and contour complexity. Twenty untrained listeners evaluated sound gestures inherent in real-world sounds, e.g., pitch contour when switching a vacuum cleaner on and off, loudness contour of a ball dropping. Participants evaluated 28 real-world sounds in three variants and had to identify the sound gesture among four visualised options while also inferring the underlying realworld source or cause. Based on features describing the macro contour of gestures (see figure), participants correctly identified 84% of all gestures (above chance level). Manipulated sounds that emphasised gesture salience only yielded slight improvements of identification compared to original real-world sounds. Furthermore, performance on gesture and source/cause identification did not correlate, suggesting task independence. Overall, findings suggest that untrained listeners perceive sound gestures and can reliably use them to form crossmodal associations. For one, this suggests that the perception of environmental sounds may evoke crossmodal links, while the reliable identification of sound gestures highlights their utility to auditory displays or crossmodal interfaces.

## #157- Learning to augment visual depth perception with a new audio cue

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Atypical sensory development provides opportunities for major reorganisation of sensory processing. However, much less is known about plasticity in healthy adults. Here, we ask how perceptual depth computations change as healthy adults learn to use new audio cues to depth. Two studies in immersive VR measured the benefits of a new echo-like audio cue for distance estimation after short training. A key question was whether the new cue was integrated with visual cues. We found precision gains and reliability-reweighting indicating that cues were integrated; however, precision gains were less than predicted by optimal integration. This suggests that reliability-weighted cue integration, a key multisensory computation, may be rapidly deployed with newly learned sensory cues, but less efficiently than with familiar cues. Two subsequent studies used desktop psychophysical tasks to directly compare interactions between stereo disparity and (i) a new audio cue to depth (pitch); (ii) a familiar visual cue to depth (size). Cues were reweighted by reliability, and there were near-optimal precision gains associated with combining familiar cues, but not new cues. Combination-associated precision gains were significantly stronger with familiar than new cues in a direct within-subjects comparison. A follow-up study, including longer interactive visuo-motor training in a small-N design, will allow for conclusions about computation and learning in individual participants. These studies are mapping out conditions under which people's abilities to interact intuitively with new signals and devices may be optimised, and provide a platform for ongoing investigations of neural correlates and subjective experiences associated with learning new sensory skills.

## #158 - Reset of low-frequency oscillations in auditory integration areas during audiovisual speech

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Background: Audiovisual speech confers a perceptual advantage over auditory speech alone by improving detection and discrimination capabilities. Prior research suggests this advantage arises from preparatory mouth movements associated with audiovisual speech. The neural mechanisms for audiovisual integration into a unitary percept remains an active research area. Objective: We aim to investigate whether audiovisual, auditory, and visual-only speech resets the phase of neuronal oscillations in auditory integration areas. Methods: We analyzed eight participants' neural responses recorded from electrodes implanted over the superior temporal gyrus (STG) and supramarginal gyrus (SMG). We compared the phase of neural responses from 2-4 Hz during the presentation of mouthleading (ML) and voice-leading (VL) words shown during auditory, audiovisual, and visualonly conditions. Results: We found a significant increase in the intertrial phase coherence (ITPC) during the presentation of ML and VL words shown during auditory and audiovisual conditions. In left structures the maximum peak of the ITPC was significantly larger during the presentation of words presented in an audiovisual condition in comparison with auditoryonly words. Conclusions: These results suggest that auditory-only, visual-only, or audiovisual speech can modulate the phase of low-frequency oscillations.

## #159 - As light of your footsteps: Investigating individual differences in the perception of own-body weight through auditory illusions

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Own-body perception is shaped by multisensory signals and prior knowledge. Modifying the frequency spectra of self-produced walking sounds has shown to alter such perception. These alterations can make the body feel heavier/lighter, slower/quicker, more masculine/feminine, and alter emotions and gait patterns. Individuals with eating disorders have exhibited distinct effects from this paradigm, showing perceptions of a heavier body even for acoustic signals consistent with a lighter body. We aimed to replicate and extend the previous findings on a larger scale with 100 participants by using an improved setup, including a highly portable digital audio system, a full-body motion capture suit, and physiological sensors. Participants were pre-screened regarding eating disorder symptomatology and physical activity levels. Results so far replicated prior findings of heavier/lighter perceptions based on sound changes, according to self-reports and body visualizations. Data collection for some subsamples is undergoing, but preliminary results for individual differences in the illusion according to the pre-screening criteria will be presented. Further exploratory data on the effects of social support networks and sensory imagery will be outlined. Finally, a preliminary pipeline to release the created database and apply machine learning techniques to find relationships between sensor data and body perception measures will be discussed together with its potential impact. This study highlights the role of body transformation technologies that may be transparent (i.e., not interfering with other sensory aspects), portable, and potentially used in real-world settings, thus paving opportunities to support people with eating disorders and low physical activity levels.

## #160 - How humans divide space when retrieving spatial location from memory

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Humans divide space into categories, which provide a fundamental source of information used to structure our perception of the world. For instance, in remembering the location of a dot in a circle, humans implicitly divide the shape into four quadrants, and their reproductions from memory are biased towards the center of each of the resulting quadrants. These systematic biases suggest that the memory for actual stimuli is combined with central categorical information, which is based on the division of the enclosing space surrounding the remembered object. Here, we explored whether the space surrounding a landmark is also broken up into spatial categories when organized in memory, or, on the contrary, whether the use of spatial categories only emerge in enclosed spaces such as shapes. To this aim, we tested localization from memory of dots presented in the space around a landmark placed in an empty background, where no surround can help segmenting the space. We observed that localization responses from memory were biased towards specific subregions around the landmark. Thus, people divided the surrounding space of the landmark into four sub-quadrants to help retrieving the location of the dot from memory. The imaginary size of these spatial subdivisions was based on the history of previous localizations. These results suggest that the use of spatial categories is a highly prevalent and dynamic phenomenon during spatial localization from memory, that goes beyond the subdivision of the enclosing space within an object, but it affects any landmark that is used to retrieve the location of an object.

## #162 - Audio-visual integration is better in older adults with a ten-year high level of physical activity

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Evidence is accumulating on the association between exercise and multisensory integration. Along those lines, a recent review indicated physical exercise as a potential avenue for training multisensory processing. Studies looking at immediate benefits of one bout of exercise, as well as long-term habitual exercise, support the hypothesis of a potential link. In this contribution we provide novel evidence for the association between susceptibility to the Sound-Induced Flash Illusion and levels of physical activity (International Physical Activity Questionnaire) over ten years, in the Irish Longitudinal Study on Ageing (N= 2,974 adults aged 50+). We analysed the accuracy of response to illusion trials with generalized logistic mixed effects regression models, adjusted for a number of covariates. Lower susceptibility to the illusion was associated with higher level of physical activity over ten years. The results confirm the association between multisensory integration and physical exercise over middle and older age.

## #163 - Brain-wide imaging of multisensory integration in poly(I:C)-induced maternal immune activation model of autism with volumetric functional ultrasound imaging (vfUS)

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Our study is focused on multisensory processing, which is the mechanism that combines different sensory inputs to produce a result different from their individual components. Such a process is essential for perception and behavioral response, which provides adaptative advantages in survival. Autism Spectrum Disorder (ASD) is a range of neurodevelopmental disorders characterized by social and communication deficits as well as repetitive behaviors. Sensory processing anomalies, including deficits in multisensory integration, are common in individuals with ASD. Therefore, we propose to compare multisensory processing between wild-type mice and poly(I:C)-induced maternal immune activation model of ASD. The circuits of multisensory processing are widely distributed across the brain, and it is essential to probe large-scale neural dynamics with high spatiotemporal precision to understand the underlying neural circuits. For this purpose, we used state-of-the-art volumetric functional ultrasound imaging (vfUS) in awake wild-type and autistic mice to assess the hemodynamic responses evoked by three senses (touch, audition, vision) and their combination throughout the brain. Our preliminary data show that vfUS allows the visualization of each unisensory circuit throughout the brain. This project is a first step toward using vfUS technology to identify targets for treating and potentially diagnosing autism in the future.

## #164 - Common neural assemblies for facial and vocal emotion expressions as evidenced by intermodulation frequency EEG

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Effective social communication depends on the integration of emotional expressions coming from the face and the voice. Although there are consistent reports on how seeing and hearing emotion expressions can support and influence each other, revealing a direct signature of multisensory integration non-invasively in humans remains challenging. Here we implemented a multi-input EEG frequency tagging paradigm to investigate whether there are neural populations that concurrently process and integrate facial and vocal emotion expressions. We acquired high-density EEG (128 channels) while participants attended to dynamic fearful facial and vocal expressions tagged at different frequencies (fV, fA). Beyond EEG activity at the facial and vocal emotion presentation frequencies, activity at intermodulation frequencies (IMF) arising at the sums and differences of the harmonics of the stimulation frequencies (mfV ± nfA) were observed, suggesting integration of the visual and auditory emotion information into a unified representation. These IMF provide evidence that common neural populations integrate signal from the two sensory streams. Importantly, IMF responses were absent in a control condition with mismatched facial and vocal emotion expressions. Our results provide direct evidence from non-invasive recordings in humans for common neural populations that concurrently process and integrate facial and vocal emotional cues.

## #165 - Allostatic load is associated with susceptibility to the Sound-Induced Flash Illusion in the Irish Longitudinal Study on Ageing

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The impact of allostatic load (AL) (i.e., the effect of exposure to chronic stress, which can accelerate ageing) on multisensory perception remains largely unknown. We explored the relationship between multisensory integration, measured with the Sound-Induced Flash Illusion and AL in 1,358 adults aged 50+ from The Irish Longitudinal Study on Ageing at multiple audio-visual temporal asynchronies. AL included markers of the main bodily systems: immunological, cardiovascular, metabolic, and renal. We analysed the accuracy to illusion trials of a SIFI task with generalised logistic mixed effects regression models, adjusted for a number of covariates. Cross-sectional and longitudinal results revealed that higher SIFI susceptibility with larger temporal asynchronies was associated with higher AL. We speculate that this association could be related to the modulation of the neurotransmitter GABA, associated with AL, which was associated with Gamma Band oscillations and SIFI in previous work.

## #166 - Cue Combination for Weight Perception with Familiar and Novel Visual Cues

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The precision of human perception is enhanced through the combination of redundant sensory cues, in a range of perceptual contexts. However, it is unclear whether weight perception is enhanced through the combination of visual cues and haptic cues. We investigate this, in one experiment using familiar visual cues, and in a second experiment using a novel cue, not usually associated with weight. We hypothesised that weight discrimination will be more precise when given visual and haptic cues together compared to either alone. In the first experiment, 32 participants completed a two-alternative forced-choice weight discrimination task in three conditions. In the visuo-haptic condition, participants held the jars while viewing their contents. In the visual condition, participants only viewed the jars and their contents. In the haptic condition, participants held the jars without seeing their contents. In the second experiment, the contents of the jars were not visible; instead, the jars were textured with line orientations, mapped to their weights. Participants received 90 minutes of training to learn orientation-to-weight mappings. In the first experiment, performance was significantly better ($p < .001$) with both cues present, suggesting participants combined familiar visual and haptic cues. In the second experiment, preliminary data from ten participants shows that all successfully learned the orientation-to-weight mapping, though only six participants' performance was best in the visuo-haptic condition. Results from these two experiments will let us draw conclusions about the possibilities of integrating novel sensory cues with familiar ones for enhanced perception and action.

## #167 - The development of the visuo-tactile temporal binding window for infants aged 4- to 8-months-old

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Previous studies have shown that audio-visual temporal binding windows decrease in duration from infancy to adulthood. But this developmental trend may not be seen across all sense pairings (e.g., due to differences in the sensorimotor biomaturational constraints across sensory modalities). Here we investigated whether there are developmental changes in visuo-tactile temporal binding between 4-8 months of age concerning visual and vibrotactile stimuli presented on infants' feet. This age range was chosen as infants typically develop reaching behaviour (another visuo-tactile skill) during this age span. Therefore, a short reaching task was also carried out to explore potential connections between this ability and infants' visuo-tactile temporal binding. Infants were first habituated to vibrotactile and visual stimuli presented simultaneously. Stimuli were presented for 700 milliseconds on alternating feet with an interstimulus interval of 1500 milliseconds. Trials continued until the infant looked away for 2 continuous seconds. Once an infant had reached habituation criterion (50% less total looking across the most recent 3 trials than in the first 3 trials), they were presented with four test trials: the familiar synchronous trial and three asynchronous trials (where the light's onset was delayed by 100ms, 250ms, and 400ms respectively). The order of these four test trials was counterbalanced across infants. Infants' total looking times in each test trial were recorded, along with their age (in days), sex, and reaching ability. Preliminary findings from 28 participants indicate that infants are able to segregate visual and tactile stimuli presented with 100ms between them across the age range.

## #168 - Brief postnatal visual deprivation alters face identity processing in the human fusiform face areas

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Adult expertise in human face processing is prominently supported by face-sensitive regions located in the ventral occipito-temporal cortex (VOTC). Previous studies have provided inconsistent results on how a transient period of early visual deprivation alters face-specialization in this network. Here, we characterized the brain activity of bornblind individuals treated for dense bilateral congenital cataracts before 7 months of age (CP) and sighted controls (SC) during three fMRI experiments testing face-categorization and face-identity adaptation. In the latter experiment, faces were presented to the participants either at a slow (2Hz) or rapid (6Hz) pace to assess the ability of brain regions to rapidly refresh their functional tuning across different faces, a crucial ability for efficient face processing. We observed a preservation of the categorical response to faces in both the experiments contrasting (1) faces vs cars and (2) faces vs houses. Nevertheless, a significant reduction of release from identity-adaptation was observed in CP when compared to SC that affected more severely the (anterior) mid-FFA portion, bilaterally. Additionally, CP showed higher face-identity adaptation in the right ventral extrastriate body area and reduced connectivity between mid-FFA and the anterior temporal pole. Our results suggest that transient visual deprivation early in life does not prevent categorical face tuning in VOTC, but it can impact on typical face identification at higher stimulation rate, as well as on the functional dissociation of face/body-sensitive regions. In turn, this might alter the functional interregional coupling of mid-FFA with regions in the anterior temporal cortex implicated in face recognition

## #169 - Feeling touch through sight: behavioral and neurophysiological evidence of tactile perception beyond the own body boundaries

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Touch is strongly related to the bodily-self, forming the boundary between one's own and others' bodies. Previous studies investigated the relationship between touch and bodyownership (i.e., the feeling that body-parts belong to us) demonstrating that somatosensory experiences arising from the skin are at the root for a coherent sense of body-ownership. Neuropsychological evidence suggests that brain-lesions inducing bodyownership delusions lead patients to feel touches onto another's body, suggesting the potentiality of sensing touches even beyond the own body boundaries. Against this background, we focus on the role of body-ownership in gating tactile awareness, asking whether the belief of owning a body part determines the ability to perceive tactile sensations on it. To this aim, we exploited the Rubber Hand Illusion, inducing a feeling of ownership onto a fake hand, combined with a tactile task. During the experiment, following repeated periods of illusion induction (synchronous and asynchronous), tactile events randomly occurred on either the fake (visual-touch) or the own (real-touch) hand. Through a VAS scale, we collected somatosensory reports related to both visual- and real-touch and, by combining EEG with TMS pulses over S1 contingent upon tactile events, we analyzed the touch-related neural dynamics. Tactile perception increased at the sight of touches occurring onto the fake (embodied) hand, while it decreased when the own (disembodied) hand was touched. The S1 alpha-band connectivity fully paralleled the diametrical modulation of tactile perception, providing evidence of the neurophysiological blueprint of the inner potentiality of the brain of sensing a visual touch.

## #170 - Improving self-motion perception with training in younger and older adults

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Older age is associated with changes in multisensory integration during self-motion perception, as well as declines in the ability to perceive visual self-motion specifically (e.g., heading estimation). For instance, about 25% of older adults (OAs) cannot perceive heading from visual motion alone. Multisensory training can benefit unisensory perception and we have shown that visual + vestibular training is effective in improving visual-only heading perception (Gabriel et al., 2022, FANS). It is unclear, however, if visual training alone could also improve visual self-motion perception. Therefore, the objective of this study was to examine if visual training could be used to improve visual heading perception to the same extent as multisensory training. Here, we simulated forward visual motion through a virtual starfield display and asked physically stationary older and younger participants to judge whether they had been moved to the forward-left or forward-right. Using an adaptive staircase procedure, we measured their heading bias and precision. Participants then received 900 customized training trials with feedback ('correct'/'incorrect') over three days. Preliminary results replicated the finding that around 25% of OAs could not perceive visual heading pretraining. Post-training results (n = 10 OAs) indicated that visual heading training may not be sufficient to significantly improve visual heading estimation. Together, these results are consistent with previous literature suggesting that unisensory (vs. multisensory) training may be less effective at improving perceptual estimates in unisensory tasks, here in the context of self-motion perception.

## #171 - The Illusion of Tilt: Does Your Sex Define Your Perception of Upright?

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During centrifugation, participants often experience an illusionary tilt of their body (somatogravic illusion) based on the gravito-inertial acceleration (GIA). In a pilot study (4f, 4m), we observed an unexpected sex difference regarding this illusion. Participants were asked to align a rod to their perceived upright (subjective haptic vertical; SHV) Females aligned their SHV with Earth's gravity vector reflecting no somatogravic illusion. Males showed the illusion. In this study, perceived orientation was measured by having 39 blindfolded participants (20f, 19m) indicate their SHV while lying supine in two different body orientations (headin, head-out) on a centrifuge. The direction of the GIA was pseudo-randomized varying between 0° (i.e., 0g - no rotation) and ±45° (i.e., 1g) in 0.33g (i.e., 15°) steps. Control trials were conducted using physical tilts with the same angles and body orientations as on the centrifuge. Data was normalized to reflect participants' perceived tilt. The results did not replicate the sex effect found in the pilot. Females perceived physical tilts to be larger in comparison to the illusionary tilts on the centrifuge. Furthermore, both females and males perceived tilts to be larger when being head down / out, except for the 0° angle. We cannot support the pilot study's results, but females perception of "down" differs between illusionary and physical tilts, while males does not. Interestingly, in both sexes illusionary and physical tilts are perceived differently depending on their body orientation. These findings are important for situations where humans could misinterpret accelerations as tilts, e.g. pilots.

## #172 - Cross modal interactions in the categorical perception of familiar objects

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The brain's ability to organise object information into distinct categories, known as Categorical Perception (CP), supports more efficient recognition despite similarity across items. CP has classically been demonstrated for visual (e.g., colour) and auditory (e.g., phonemes) stimuli. More recently CP effects were found for more complex visual stimuli such as objects and faces, suggesting it is a common principle of information processing for object recognition. Little is known about how multisensory information affects the formation object categories in memory. To address this, we first created continua of familiar object shapes in which the object extremes belonged to either the same (e.g., beer or wine glass) or different (e.g., bell and bottle) semantic categories. The results of our initial study established that the perceived visual similarity between object stimuli was dependent on the nature of the category, with higher similarity ratings for objects within than across categories. We then investigated whether CP effects are more pronounced for multisensory than unisensory object categories. Participants were allocated to different category learning conditions (visual-only, bimodal congruent, bimodal incongruent, bimodal irrelevant) and subsequently performed visual discrimination and categorization tasks based on visualonly information. Our results suggested a benefit for semantic learning conditions on categorisation and discrimination, however the findings were specific to certain object categories, consistent with previous research. This research offers insights into the formation of perceptual multisensory categories of familiar objects and their representation in memory.

## #173 - Seeing is not feeling but perspective matters: ERPs of touch observation

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Previous touch observation studies have suggested that when we observe touch on another person we simulate this experience in our own body representation including primary somatosensory cortex (SCx). Yet, fMRI studies which demonstrate such effects cannot distinguish between early perceptual and later post-perceptual feedback activations of SCx, and furthermore, have been argued to be prone to mis-localisations. We took advantage of the good time resolution of ERPs, and in contrast to previous studies which used a congruency design, we optimised potential touch observation effects by making the touch condition visible from trial onset. Furthermore, by probing SCx activity on half of the trials we could track touch observation effects on SCx's hierarchical processing stages and tease apart visual carry over effects from SCx activations. We used two touch observation conditions, one contrasting touch and notouch (employing a screen positioned in front of the touch location), and the other contrasting different touch textures (soft/foam and hard/solid). We did not find any reliable modulation of early (P50) or later (LPC) SCx components; but we did find spill over effects on a go/no-go task presented after each touch observation consistent with post-perceptual effects. Interestingly, we found a strong effect on early and mid-latency SCx components when we asked participants to imagine feeling the observed touch. Taken together, our study provides evidence of absence of touch observation effects on early somato-perceptual processing and shows voluntary rather than automatic SCx engagement.

## #174 - Structural and functional maturation of posterior parietal cortex during adolescence facilitates cross-modal brain plasticity in adulthood

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Sensory loss can lead to a cross-modal takeover of cortical territory by the spared senses. In the adult monocular enucleation mouse model of such cross-modal plasticity, the deprived visual cortex (V1) becomes reactivated by the spared somatosensory modality (S1). To create knowledge about the intricate cortical network that drives this recovery, we initiated a connectome study to validate that this plasticity process relies on the posterior parietal cortex (PPC) as a hub to transfer sensory information from S1 to V1. The PPC consists of several sub-areas, and we identified that sub-area RL receives more S1 connectivity. To verify if the PPC can relay somatosensory information towards V1, we used a mono-trans synaptic pseudo rabies virus, confirming an indirect and functional cortico-cortical pathway from S1 via PPC sub region RL, to V1. The somatotopic nature of the projections to RL were further confirmed by multi-colored anterograde tracing. By pharmacologically inhibiting activity of this circuit, after cross-modal plasticity, we were able to reduce the new neuronal activity in V1, as measured by zif268 expression in V1. We thus identified an anatomical substrate that can carry somatosensory inputs to mouse V1 upon late-onset vision loss. In stark contrast, this plasticity phenomenon does not occur in V1 of adolescent mice. We hypothesized that this brake relates to a delayed PPC maturation. Using typical markers of critical period, we confirmed a gradual maturation of the different PPC subareas during adolescence. In conclusion, we identified a clear role for associative multimodal cortex in cross-modal brain plasticity.

## #175 - A multimodal generative model for the development of reaching to the body from self-touch

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Already in the womb, fetuses engage in spontaneous activity which also includes self-touch. After birth, as they grow and interact with their environment, these behaviors mature alongside their neural circuitry. Despite changes due to growth, the body remains ``the most consistent, the most predictable, and the most verifiable part of the environment'' (Stoytchev 2009). We study how stable and rich sensorimotor contingencies obtained during self-interaction, especially self-touch but also self-vision, scaffold body perception in newborns. Inspired by a series of studies examining infants' ability to reach for a stimulus placed on the skin, we propose a general unsupervised learning mechanism. The mechanism integrates raw sensorimotor inputs into a multi-modal self-interacting map, without relying on explicit body maps in each modality. The proposed computational model uses a variational autoencoder architecture and fuses proprioceptive and tactile population codes into a multimodal latent space representing selftouch configurations. The latent code generates top-down predictions of self-touch configurations as desired body states. The multimodal latent space encodes body structure information like the topography of tactile sensors, as the ability to perform self-touch on specific skin positions. The model is trained on a simplistic model of the human torso in two dimensions with skin, and two arms with three degrees of freedom each. Learning is through gradient descent from random motor babbling data. The architecture attempts to give a functional account of self-touch development to explain reaching emergence in newborns.

## #176 - Temporal integration of audio-visual stimuli in the mouse superior colliculus

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The relative timing of different sensory input signals is an important factor in multisensory integration and perception. When multiple forms of sensory stimuli arise from a single source, the degree of synchrony in the arrival of these stimuli can provide distance cues. The difference between the velocities of light and sound introduces a distance dependent lag for auditory signals with respect to visual information. Audio-visual delays therefore carry information about the distance to the stimulus source. Here we investigated the representation of audio-visual delays in the mouse superior colliculus (SC), a midbrain area that represents the location of visual and auditory targets topographically. Neuronal activity was recorded with Neuropixels probes in awake animals presented with visual and auditory stimuli with staggered onset times (ranging from 0 to 100ms). We found that 30% of the recorded neurons are modulated by both visual and auditory stimuli. These neurons exhibit a broad range of audio-visual delay preferences and exhibit nonlinear multisensory interactions. We used a random forest classifier to decode audio visual delays from population responses. We found differences in decoding performance across the anteriorposterior and the medio-lateral axes of the SC, with the highest accuracy in the posteriormedial region. This result suggests that there is a functional specialization of multisensory integration across anatomical regions of the SC. While separability of audio-visual delay representations is enhanced in the upper visual field, perceptual binding is favoured in the lower visual field.

## #177 - Increased multisensory gain in older adults may be a byproduct of inverse effectiveness: Evidence from a speeded response-time task

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Older adults experience greater multisensory gain than their younger counterparts. Agerelated sensory decline, coupled with inverse effectiveness, may lead to this increase in multisensory gain. That is, sensory decline weakens unisensory stimulus effectiveness, causing a boost in multisensory gain. Alternatively, heightened multisensory gain in older adults may be due to changes in mechanisms underlying multisensory processing that may act as a compensatory mechanism. To examine these two explanations, we used two audiovisual detection tasks. In the first, we presented auditory (pure tones in noise), visual (Gabor patches in noise), and audiovisual stimuli and recorded response times. Importantly, all participants were given identical stimuli, with the expectation that older adults would show worse unisensory performance, inducing inverse effectiveness. The second task was identical, except stimuli were presented at each participant's 50% detection threshold, identified with an adaptive psychophysical staircase, controlling for any influence of inverse effectiveness. If older adults exhibit greater multisensory gain (as measured by race-model violations) in both tasks, it suggests that there are age-related changes in multisensory processing. However, if older adults exhibit greater gain in the stimulus- but not perception-matched task, agerelated increased gain may be attributable to inverse effectiveness. Early results indicate that in the stimulus-matched task, older adults (N=4) experience greater multisensory gain than younger adults (N=7, Cohen's d=1.30, data collection ongoing). In contrast, in the perception-matched task older (N=31) and younger (N=30) adults experience comparable multisensory gain (Cohen's d=0.13). This suggests that greater multisensory gain among older adults may be attributable to inverse effectiveness.

## #178 - Visual Perception Modulates Reactions to Misophonia Trigger Sounds

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Misophonia is characterized by strong negative reactions to everyday sounds, such as chewing, slurping, or breathing, that can have severe negative consequences for daily life. Here we investigated the role of visual stimuli in modulating misophonic reactions. We recruited 31 misophonia and 26 healthy controls and presented them with 26 sound-swapped videos: 13 misophonia trigger sounds (e.g., crunchy chewing) paired with the 13 original video sources (OVS; e.g., video of crunchy chewing) and with 13 positive attributable visual sources (PAVS; e.g., video of tearing a piece of paper). After each video, participants rated the pleasantness and the intensity of bodily sensations felt and had the option to describe the nature of these sensations. Our results show that PAVS-paired sounds significantly increased ratings of pleasantness and reduced the negative bodily sensations in both misophonia and control groups, compared to OVS-paired sounds. Importantly, participants with misophonia showed significantly more reduction in bodily sensation ratings compared to the control participants. An analysis of self-reported bodily sensation descriptions revealed that PAVS-paired sounds led to qualitative changes in these descriptions among misophonia participants, resulting in fewer words pertaining to body parts. We also found that participants who scored higher on the Duke Misophonia Questionnaire (DMQ) had higher auditory imagery scores, yet visual imagery was not associated with the DMQ. Overall, our results show that the negative physical impact of misophonic trigger sounds is attenuated by presenting them alongside positive attributable visual sources.

## #179 - Understanding constraints on supernumerary embodiment using the Anne Boleyn illusion

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Multisensory illusions have been used to demonstrate the malleability of body representations. In the Anne Boleyn illusion, simultaneous stroking of the participants' fifth finger behind a mirror while stroking empty space near the mirror-reflect hand results in the strong sense of having a fifth finger. We then used this illusion to understand what constraints supernumerary embodiment – the illusory alteration of one's own body plan. In Experiment 1, we examined three aspects: anatomical plausibility, spatiotemporal congruence, and postural congruence. Given evidence from the rubber hand illusion, one would expect no illusory embodiment when the sixth finger was a different shape than typical fingers, when the mirror and viewed hands were in different postures, and when stroking differed. Surprisingly, the illusion was persistent in most variants, including those with curved fingers, elongated fingers, and postural mismatches. In Experiment 2, we parametrically manipulated the orientation, shape and length of the illusory sixth finger. The illusion was robust, with a significant reduction observed only when the sixth finger was far from the hand, or in a very implausible posture. These results provide evidence that body representations allow for supernumerary embodiment in conditions not observed in other body illusion. We propose that bottom-up information from concurrent visuotactile input, the supernumerary nature of the illusion, and reduced constraints provided by the "blank canvas" of empty space, result in a particularly robust illusion.

## #180 - Investigating the bidirectional interaction between multisensory integration and selective attention in the context of naturalistic audiovisual speech

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Seeing a speaker's face significantly improves speech comprehension, particularly in noisy environments. This is attributed to the brain's ability to combine information from auditory and visual modalities through a process called multisensory integration (MSI). In addition, real-life listening environments often contain multiple competing speech sources and listeners are typically interested in attending to just one of those – a challenge known as the 'cocktail-party problem'. Successful communication involves both MSI of audiovisual speech and selective attention, but how these processes interact is not well understood. Existing studies suggest that this interaction can be bidirectional: top-down attention can modulate MSI, while pre-attentive MSI can facilitate selective attention in a bottom-up manner. However, most previous studies used relatively controlled stimuli and paradigms that do not reflect the sensory challenges faced in the real world. Here we present a series of EEG experiments aimed at examining how attention and multisensory integration interact in the context of natural, continuous audiovisual speech. The experiments differ in complexity, number, and location of the audiovisual stimuli in such a way as to allow us to assess top-down vs bottom-up interaction between attention and MSI. Using an EEG modeling framework, we show strong effects of selective attention on indices of audiovisual speech integration and a strong influence of MSI on participants' ability to solve the cocktail party problem. Overall, our results suggest a flexible interplay between attention and MSI in the context of natural audiovisual speech, depending on the task and the environment.

## #181 - Crossmodal postdiction in the illusory audiovisual rabbit paradigm

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Perception is shaped by the processing of information entering our sensory system within a temporal integration window surrounding a stimulus. Interestingly, not only inputs preceding a stimulus, but also events following a stimulus can postdictively influence perception. Furthermore, it has been proposed that crossmodal interactions within the temporal integration window can also lead to postdictive effects. In a series of behavioral experiments, Stiles et al. (2018; PloS One 13:e0204217) demonstrated that an illusory visual stimulus can be induced by a rapidly following auditory stimulus ("illusory rabbit"). Likewise, the perception of a visual stimulus can be postdictively suppressed by an auditory stimulus ("invisible rabbit illusion"). Our behavioral study aimed at replicating both crossmodal illusions, while introducing new conditions to test whether the illusory perception is not the result of response bias or other confounding factors. To this end, we conducted two behavioral experiments that included critical control conditions, which were not used in the original studies. We replicated the main findings of Stiles et al. and showed that temporal asynchrony reduces the illusions. Moreover, we found that the illusions cannot be explained by a simple response bias. Taken together, our results support the idea that postdictive crossmodal processes can modulate multisensory perception.

## #182 - Good vibrations? Can we use smartphone browsers to present vibration stimuli for multisensory research?

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Smartphones are an accessible method for delivering tactile stimuli in remote online testing scenarios. However, to date, very few studies have been published using smartphones to deliver vibration stimuli. Pomper et al., (2014) used a single smartphone device, in the lab, to deliver vibration, visual and auditory stimuli - participants were faster for multisensory combinations of stimuli compared with unimodal presentation, producing the well known effect termed the Redundant Target Effect (RTE). Here, we explored whether the RTE could be reproduced "in the wild" by delivering stimuli remotely to participants via their smartphone devices. Participants were presented with simple unimodal, bimodal or trimodal combinations of visual, auditory, or tactile targets (a 500ms white screen, a 1000Hz tone or a vibration). The intensity of all targets were first perceptually matched to the vibration via a staircase procedure. Participants were then asked to respond as quickly as possible to target stimuli. A strong RTE was observed, with participants showing the strongest response time benefits (>100ms) for visual and auditory targets paired with tactile (vibration) stimuli, compared with unimodal presentation. We conclude that smartphone vibrations can be used as a stimulus in remote multisensory testing. We also further these findings to discuss how we can manipulate smartphone vibration to produce more complex stimuli for tasks such as multisensory category perception, for instance through manipulating tempo, rhythm and duration.

## #183 - Long-term consequences of premature birth on semantic representations of objects

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The present study investigated the long-term effects of premature birth on auditory sensory and semantic processing. Preterm-born children and full-term controls were tested at 10 years old with an auditory oddball task, while 64-channel auditory evoked potentials (AEPs) were recorded. Sounds consisted of living (animal and human vocalizations) and manmade objects (e.g. household objects, instruments, and tools). The oddball object category changed across blocks of trials, and only AEPs to frequent, non-oddball stimuli were analyzed. Groups did not differ behaviorally. However, differential patterns of AEP responses were observed between full-term and preterm children. Over the 108-224ms post-stimulus period, full-term children showed stronger AEPs in response to living objects, whereas prematurely born children showed the reverse pattern; i.e. stronger AEPs in response to manmade objects. Differential brain activity between semantic categories could reliably classify children according to their preterm status. Moreover, this opposing pattern of differential responses to semantic categories of sounds was also observed in source estimations within a network of occipital, parietal and frontal regions. This study highlights how early life experience in terms of premature birth shapes sensory and object processing later on in life.

## #184 - Experience is required to develop visual-nonvisual multisensory integration capabilities

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Using the multisensory neuron in the cat superior colliculus (SC) as a model, we found that the brain develops its ability to integrate visual and non-visual (auditory and/or somatosensory) stimuli during early postnatal life based on experience with specific cross-modal combinations. For example, precluding visual-auditory experience by rearing animals in darkness or omnidirectional masking broadband sound blocks the maturation of visual-auditory integration capabilities. Individual SC multisensory neurons fail to show their characteristic ability to synthesize inputs from congruent visual-auditory cues and thereby enhance their responses. Animals also fail to show normal multisensory performance benefits, retaining the neonatal or “default” computation whereby these sensory inputs inhibit one another. This condition is only modestly ameliorated when such animals are exposed to a normal environment as adults. However, the defect can be overcome via special multisensory training paradigms in which spatiotemporally congruent visual-auditory stimulus pairs are repeatedly presented at a single location in space. With this exposure, visual-auditory SC neurons whose receptive fields encroach on the exposure location change their multisensory computation from competition to one in which congruent visual-auditory stimuli elicit the enhanced responses typical of the normal brain. These physiological changes are paralleled by changes in behavior: after multisensory training, the detection and localization of congruent visual-auditory pairs are now greatly enhanced at the exposure location. These findings reinforce that multisensory experience is crucial for multisensory development at all ages, and that multisensory training can greatly accelerate this development in adults relative to the uncontrolled multisensory experience offered by normal environments.

## #185 - Rehabilitating hemianopia with multisensory training

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Unilateral damage to visual cortex commonly results in a profound contralateral blindness (hemianopia) that is largely regarded as permanent. We have developed a promising non-invasive sensory rehabilitation paradigm using an animal model in which all contiguous areas of visual cortex are lesioned. The paradigm involves repeatedly presenting spatiotemporally congruent visual-auditory stimuli in the blinded field, which engages the brain's inherent mechanisms for multisensory processing and plasticity. The repeated coupling of visual and auditory signals boosts visual sensitivity within the intact ipsilesional secondary visual pathway, rapidly restoring visual responsiveness in the multisensory output layers of the superior colliculus and visually-guided behaviors everywhere in contralesional space. The rehabilitated visual capabilities include the ability to discriminate visual patterns and are robust to competitive stimuli presented simultaneously in the intact field. Repeatedly presenting individual visual or auditory stimuli, or spatially or temporally incongruent visual-auditory pairings, are not effective in rehabilitation. To determine if this technique represented an effective rehabilitative approach for humans, two patients rendered hemianopic by stroke were recruited for a study. Patients were given repeated exposure to spatiotemporally congruent visual-auditory stimuli in their blinded field in weekly sessions and, within weeks, recovered the ability to detect and localize lights presented alone. This detection was robust to competition from the intact field. Patients could describe some features of visual stimuli in the rehabilitated field and reported substantial improvements in quality of life. These results provide proof-of-concept that multisensory training represents an effective technique for the rehabilitation of hemianopia in humans.

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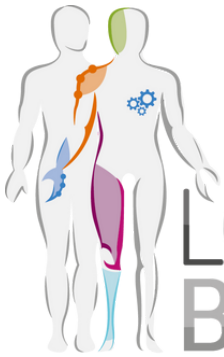
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