IMRF 2015

Pisa 13th – 16th June 2015

ABSTRACT BOOK

SYMPOSIA

LECT.1 MULTISENSORY BENEFITS IN SELF-MOTION PERCEPTION

Dora Angelaki

Baylor College of Medicine - Houston - Texas, US

Saturday 13th June – Auditorium 6.00 pm

A fundamental aspect of our sensory experience is that information from different modalities is often seamlessly integrated into a unified percept. Many studies have demonstrated statistically optimal cue integration, although such improvement in precision is small and often negligible. Another important property of perception is accuracy. Does multisensory integration improve accuracy? We have investigated this question in the context of visual/vestibular heading perception. Humans and animals are fairly accurate in judging their direction of self-motion (i.e., heading) from optic flow when moving through a stationary environment. However, an object moving independently in the world alters the optic flow field and bias heading perception if the visual system cannot dissociate object motion from self-motion. The moving object induced significant biases in perceived heading when self-motion was signaled by either visual or vestibular cues alone. However, this bias was greatly reduced when visual and vestibular cues together signaled self-motion. These findings demonstrate that vestibular signals facilitate the perceptual dissociation of self-motion and object motion, consistent with recent computational work which suggests that an appropriate decoding of multisensory visual-vestibular neurons can estimate heading while discounting the effects of object motion. These findings provide direct evidence for a biological basis of the benefits of multisensory integration, both for improving sensitivity and for resolving sensory ambiguities. The studies we summarize identify both the computations and neuronal mechanisms that may form the basis for cue integration. Diseases, such as autism spectrum disorders, might suffer from deficits in one or more of these canonical computations, which are fundamental in helping merge our senses to interpret and interact with the world. *Introduced by Lawarence Harris*

LECT.2 SENSORIMOTOR COMMUNICATION, SPEECH AND LANGUAGE

Luciano Fadiga

Università di Ferrara

Sunday 14th June – Auditorium 6.00 pm

Despite the wide resonance evoked by the 'motor theory of speech perception' formulated by Alvin Liberman almost fifty years ago, an animated debate still survives on the possibility that speech understanding does not rely on sensory/auditory processing alone. In my presentation I will provide evidence that Liberman was substantially right and that a motor framework for speech understanding does exist. The sensorimotor association at the basis of speech processing is just an extension of a more general mechanism for inter-individual communication, as proven by recent TMS data, patients studies, and computational models, all converging in the same direction. *Introduced by Giovanni Cioni*

LECT.3 MULTISENSORY BRAIN MECHANISMS OF SELF-CONSCIOUSNESS AND VISUAL CONSCIOUSNESS

Olaf Blanke

Ecole Polytechnique Fédérale de Lausanne

Monday 15th June – Auditorium 6.00 pm

Past work has indicated that subjective aspects of consciousness, in particular the fact that consciousness is bound to the self, is based on the integration multisensory signal integration of visual, tactile, and proprioceptive stimuli in temporo-parietal cortex. Other prominent research highlighted the importance of interoceptive (bodily) signals in the insula. I will, present studies that investigate bodily self-consciousness by exposing subjects to ambiguous multisensory exteroceptive information about the location and appearance of their own body. These studies have shown that activity in a network of brain regions, centering in the temporo-parietal cortex and insula reflects bodily self-consciousness. I will then present data that show that interoceptive (cardiac) signals are integrated with such exteroceptive multisensory signals and that they are equally powerful modulators of bodily self-consciousness recruiting insular cortex. Extended by data by neurological patients, these behavioral and neuroimaging findings show that bodily self-consciousness is based on the integration of specific multisensory bodily signals within key regions in temporo-parietal and insular cortex. In a final section, I will present data revealing the impact of multisensory bodily signals for visual consciousness. These data suggest that multisensory bodily signals are not only crucial for self-consciousness, but also an important building block for perceptual consciousness, such as visual consciousness. *Introduced by Giulio Sandini*

Symposium A: MULTIPLE SENSES, MULTIPLE STIMULI: MATCHING SIGHTS AND SOUNDS AT THE COCKTAIL PARTY

Sunday 14th June – Pacinotti Meeting Room 9.00 – 11.00 am

SA.0 Introduction

Jennifer Groh

Department of Psychology and Neuroscience, Department of Neurobiology, Center for Cognitive Neuroscience, Duke University

In the real world, many stimuli are present at the same time. Multiple stimuli pose a problem for perceptual organization and for multisensory integration, as the brain must correctly determine which stimulus attributes are related across sensory modalities. For example, the sight of moving lips is useful for resolving ambiguities in speech segments but other elements of the visual scene are irrelevant. This symposium will trace the computational processes involved in connecting related visual and auditory stimuli, from single neurons in animals to neural imaging studies in humans, and considering the domains of localization, attention, recognition, and speech comprehension.

SA.1 LINKING VISUAL AND AUDITORY SIGNALS IN SPACE

J. M. Groh

Department of Psychology and Neuroscience, Department of Neurobiology, Center for Cognitive Neuroscience, Duke University

In the real world, many stimuli are present at the same time. Multiple stimuli pose a problem for perceptual organization and for multisensory integration, as the brain must correctly determine which stimulus attributes are related across sensory modalities. For example, the sight of moving lips is useful for resolving ambiguities in speech segments but other elements of the visual scene are irrelevant. This symposium will trace the computational processes involved in connecting related visual and auditory stimuli, from single neurons in animals to neural imaging studies in humans, and considering the domains of localization, attention, recognition, and speech comprehension.

SA.2 BRINGING FACES AND VOCAL STIMULI TOGETHER IN THE PRIMATE PREFRONTAL CORTEX

L. Romanski

School of Medicine and Dentistry, University of Rochester Medical Center

Romanski will describe the neural mechanisms underlying the connection of faces and voices, an essential element of social communication. She will describe how single neurons in the ventrolateral prefrontal cortex (VLPFC) of the rhesus monkey (Macaca mulatta) respond to and integrate conspecific vocalizations and their accompanying facial gestures. VLPFC neurons are sensitive to features in corresponding face and vocalizations. She will report that matching (congruent) and mismatching (incongruent) faces and vocalizations evoke different patterns of responses. Neurophysiological recordings in nonhuman primates during audiovisual working memory tasks show that VLPFC neurons retain and integrate face and vocal information during working memory which is a crucial component of communication and identity processing.

SA.3 ATTENDING TO SIGHTS AND SOUNDS BY FEATURES AND LOCATION

B. Shinn-Cunningham

Boston University

Shinn-Cunningham will consider the role of attention in selecting from among many possible matches between stimuli. She will discuss the different mechanisms employed when attention is guided by sound location versus when it is guided by other sound features, relating these differences to the way in which spatial and nonspatial features of sound are encoded. She will present results describing brain networks involved in attending to auditory versus visual inputs, and how each may be recruited by the other modality, depending on task demands.

SA.4 INTEGRATING SIGHT AND SOUND TO FACILITATE COMPREHENSION OF NOISY AND DEGRADED SPEECH

I. Johnsrude

University of Western Ontario

Johnsrude will discuss ways in which visual information may support comprehension of degraded speech. Speech perception is, in part, a predictive process, and contextual information, including visual cues, constrains interpretation of noisy and ambiguous auditory signals, rendering them more intelligible and perceptually clearer. She will present work demonstrating how the brain is organized to rapidly integrate visual information to support perception of degraded auditory signals, and that visually mediated improvements in perceptual clarity may be related to modulation of activity in early auditory areas.

Symposium B: CORTICAL PLASTICITY FOLLOWING VISUAL OR AUDITORY IMPAIRMENT

Sunday 14th June – Fermi Meeting Room 9.00 – 11.00 am

SB.0 Introduction

Stephen G. Lomber

Brain and Mind Institute, University of Western Ontario London, Ontario, Canada

Plasticity is the neural mechanism by which complex nervous systems adjust themselves to their environment. Adaptive, or compensatory plasticity is a part of this overall process resulting from the loss of a class (or modality) of sensory inputs that is accompanied by a corresponding enhancement of the remaining systems. Not only does this process provide some substitute for the lost modality, but the additional circuitry also conveys enhanced abilities to the remaining systems. Developmental studies of the deaf and blind, as well as recent studies in mature subjects, demonstrate remarkable multisensory plasticity throughout the cerebrum.The proposed symposium brings together information from both human and animal studies examining functional compensations following both hearing and visual impairment. Speakers will describe psychophysical, functional imaging, electrophysiological, and anatomical studies performed to reveal the functional consequences and underlying mechanisms of cortical plasticity following visual or auditory impairment. The symposium is designed to pair speakers working on auditory (Lomber, Cardin) or visual impairment (Mitchell, Collignon) in either animal (Lomber, Mitchell) or (Cardin, Collignon) human subjects. The proposed symposium includes a truly international group of investigators from England, Australia, Canada, and the United States working in England, Italy, and Canada. The speakers represent all career stages including new, mid-career, and senior investigators. All genders are included in the symposium. Finally, some of the proposed speakers would be first time presenters at IMRF.

SB.1 CROSSMODAL PLASTICITY IN BOTH THE DORSAL AND VENTRAL PATHWAYS OF AUDITORY CORTEX FOLLOWING HEARING LOSS

Stephen G. Lomber

Brain and Mind Institute, University of Western Ontario London, Ontario, Canada

In the absence of acoustic input, it has been proposed that crossmodal reorganization of deaf auditory cortex may provide the neural substrate mediating compensatory visual function. Here, we will examine evidence in support of this hypothesis. By using a battery of visual psychophysical tasks we found that congenitally deaf, compared to hearing, cats have superior localization in the peripheral field and lower visual movement detection thresholds. Furthermore, reversible deactivation of posterior auditory cortex selectively eliminated superior visual localization abilities while deactivation of the dorsal auditory cortex eliminated superior visual motion detection. While these results demonstrate that dorsal pathway functions can be enhanced following hearing loss, only recently have similar results been

obtained for ventral pathway functions. Here, we will show that deaf cats are significantly faster at learning to discriminate both human and conspecific faces compared to hearing cats. Moreover, bilateral deactivation of temporal auditory field (TAF) resulted in the elimination of the enhanced face (both conspecific and human) discrimination learning capabilities of the deaf cats. Unilateral deactivation of left TAF resulted in a partial, but significant, decrease in the enhanced face learning abilities of the deaf cats. These results provide evidence of a lateralization in the enhanced face learning abilities. Overall, these results show that enhanced visual cognition in deaf cats is caused by cross-modal reorganization within the ventral processing stream of ""deaf' auditory cortex. Taken together, these results demonstrate a causal link between the crossmodal reorganization of auditory cortex and enhanced visual abilities of the deaf, as well as identified the cortical regions responsible for adaptive supranormal vision.

SB.2 DEAFNESS, LANGUAGE AND NEURAL PLASTICITY IN THE HUMAN BRAIN

Velia Cardin

Deafness Cognition and Language Research Centre, University College London, London, England

Disentangling the effects of sensory and cognitive factors on neural reorganisation is fundamental for establishing the relationship between plasticity and functional specialization. Auditory deprivation in humans provides a unique insight into this problem, because the origin of the anatomical and functional changes observed in deaf individuals is not only sensory, but also cognitive, owing to the implementation of visual communication strategies such as sign language and speechreading. In this talk I will discuss functional magnetic resonance imaging studies of individuals with different auditory deprivation and sign language experience. I will show that sensory and cognitive experience cause plasticity in anatomically and functionally distinguishable substrates. I will also show that after plastic reorganisation, cortical regions preserve the nature of the computation they perform, and only adapt their function to deal with a different input signal, both at a sensory and cognitive level. Results will also highlight the fact that the human brain possesses a network that deals with a cognitive process - language, regardless of modality - spoken or signed.

SB.3 THE NATURE OF, AND NECESSARY CONDITIONS FOR, THE PLASTICITY REINTRODUCED IN THE FELINE VISUAL SYSTEM BY IMMERSION IN TOTAL DARKNESS

Donald E. Mitchell

Department of Psychology and Neuroscience Dalhousie University, Halifax, NS B3H 4R2

Recently it has been demonstrated that a short (10 day) period of complete darkness can reintroduce a heightened level of plasticity in the visual system of kittens that was demonstrated with respect to vision in two ways depending on the temporal relationship between two manipulations. In kittens made amblyopic in one eye by an early period of monocular deprivation (MD), a 10 day period of darkness imposed 8 weeks later promoted rapid improvement of the visual acuity of the deprived (amblyopic) eye to normal levels in a week or less. The ability of darkness to erase the effects of MD was limited to a critical period that lasted until about 6 months of age. A period of darkness imposed immediately after the same early period of MD, but before 10 weeks of age, had a dramatic effect on the vision of the non-deprived eye so that initially the animal appeared blind when using either eye alone. Over the next 7 weeks the vision of both eyes improved gradually in concert to eventually attain normal visual acuity. It was as if the period of darkness effectively blocked development of the usual behavioural signature of an early period of MD. However, none of the beneficial effects are observed if a short 15 min period of light is provided each day in the darkroom or after only a 5 day period of darkness. Darkness may block the maturation of various braking molecules that normally serve to reduce plasticity in the central visual pathways.

SB.4 IMPACT OF SIGHT DEPRIVATION AND RESTORATION ON THE FUNCTIONAL ORGANIZATION AND CONNECTIVITY OF THE OCCIPITAL CORTEX

Olivier Collignon

Center for Mind/Brain Sciences, University of Trento, Mattarello (TN) - ITALY

Neuroimaging studies involving blind individuals have the potential to shed new light on the old 'nature versus nurture' debate on brain development: while the recruitment of occipital (visual) regions by non-visual inputs in blind individuals highlights the ability of the brain to remodel itself due to experience (nurture influence), the observation of specialized cognitive modules in the reorganized occipital cortex of the blinds, similar to those observed in the sighted , highlights the intrinsic constraints imposed to such plasticity (nature influence). In the first part of my talk, I will present novel findings demonstrating how early blindness induces large-scale imbalance between the sensory systems involved in the processing of auditory motion. These reorganizations in the occipital cortex of blind individuals raise crucial challenges for sight-restoration. Recently, we had the unique opportunity to track the behavioral and neurophysiological changes taking place in the occipital cortex of an early and severely visually impaired patient before as well as 1.5 and 7 months after sight restoration . An in-deep study of this exceptional patient highlighted the dynamic nature of the occipital cortex facing visual deprivation and restoration. Finally, I will present some data demonstrating that even a short period of visual deprivation

(only few weeks) during the early sensitive period of brain development leads to enduring large-scale crossmodal reorganization of the brain circuitry typically dedicated to vision, even years after visual inputs.

Symposium C: **INSIGHTS AND PERSPECTIVES ON SENSORY-MOTOR INTEGRATION**

Monday 15th June – Pacinotti Meeting Room 9.00 – 11.00 am

SC.0 Introduction

Silvio Ionta

Laboratory for Investigative Neurophysiology, Dept of Radiology and Dept of Clinical Neurosciences, University Hospital Center and University of Lausanne, Lausanne, Switzerland

SC.1 FUNCTIONAL NEUROIMAGING OF SENSORY-MOTOR SYSTEMS: UNDERSTANDING INPUT-OUTPUT RELATIONS IN THE HEALTHY BRAIN

Rochelle Ackerley

Dept of Physiology, University of Gothenburg, Sweden; Laboratory for Adaptive and Integrative Neuroscience, Aix-Marseille University, France

Functional human brain imaging has provided us with a wealth of information about sensory and motor process, and how these interact at a systems level. Nevertheless, we have much to learn about the normal functioning of these processes and how we interpret incoming sensory afference to generate motor efferent output. One of the most immediate consequences of actively interacting with the environment is tactile perception. Concerning touch input, most studies have focused on the primary somatosensory cortex (S1) to investigate how tactile information is processed, but there are many other areas that contribute to decoding touch. The present session highlights the role of S1 and other areas, such as the insula and secondary somatosensory cortex, in processing touch input from all over the body. Using functional magnetic resonance imaging (fMRI), it is possible to decode the areas that are involved in the interpretation of active, self-generated touch, and the passive touch from another. A network of activity has been found to the most basic of touches, thus the afferent information is decoded not simply for the tactile element, but in terms of its relevance for behavior. Theories will be discussed that relate the intention of touch to the interpretation and motor action taken. The relevance of who is touching and where are especially important in affective processing, which is subject to strong cognitive modulation. The attention paid to touch can also regulate processing in sensory areas, which in turn feed into motor regions that determine the actions taken.

SC.2 STRUCTURAL BRAIN IMAGING APPROACHES TO UNDERSTAND SENSORY-MOTOR FUNCTION IN HEALTH AND DISEASE

Michael Borich

Neural Plasticity Research Laboratory, Division of Physical Therapy, Dept of Rehabilitation Medicine, Emory University, Atlanta, Georgia, USA

Non-invasive approaches to study human brain structure have yielded important new insights into the neural substrates that underpin sensory-motor function in both health and disease. It has been shown that differences in brain structure after injury or in the context of neurologic disorders are associated with alterations in behavior. Using structural magnetic resonance imaging (sMRI) and diffusion weighted imaging (DWI), differences in gray and white matter structure have been demonstrated after stroke. These differences have the capacity to predict levels of sensory-motor dysfunction and response to rehabilitation in patients with stroke. When combined with non-invasive brain stimulation approaches, structural imaging offers exciting novel avenues to study brain structure-function relationships contributing to normal and abnormal sensory-motor function. This session will provide a comprehensive understanding of the critical brain structural correlates of normal sensory-motor function and the restoration of function in disease, creating the opportunity to improve clinical outcomes for patients following neurologic injury or in response to other neurologic conditions affecting the sensory-motor system.

SC.3 A BIO-COMPUTATIONAL MODEL OF SENSORY-MOTOR INTEGRATION

Silvio Ionta

Laboratory for Investigative Neurophysiology, Dept of Radiology and Dept of Clinical Neurosciences, University Hospital Center and University of Lausanne, Lausanne, Switzerland

Conceiving theoretical models to explain the causal link between dysfunctional brain networks and clinical phenotypes is a major challenge in cognitive neuroscience. In the current models of sensory-motor integration the reciprocal role of sensory and motor processes is still unclear. The dissociation between sensory and motor sources of information is necessary to better understand the nature of their integration. Experimental psychology identified mental imagery, an active cognitive task that activates motor representations in absence of the appropriate sensory stimulation; a task particularly important for studying the pathophysiology of several clinical conditions. This session will shed light on behavioral evidence obtained with the implementation of mental imagery protocols in both experimental and clinical settings. The described results, together with insights on clinical observations and neural organization, will be enclosed in a broad theoretical model of modes and operations of sensory-motor processing, which will work as reference frame for the evidence reviewed in the following sessions.

SC.4 BIOMEDICAL ENGINEERING SOLUTIONS FOR SENSORY-MOTOR REHABILITATION

Calorgero Oddo

BioRobotics Institute, Scuola Superiore Sant'Anna, Pisa, Italy

Rehabilitation engineering strives to restore sensory-motor functions to disabled individuals by linking neural circuitry to artificial devices, such as computers, prosthetic limbs, wheelchairs and communication systems. In order to endow a generation of robotic prostheses with an artificial sense of touch and with the aim of restoring of natural tactile sensation and perception in upper-limb amputees, we systematically pursued neuro-robotics developments during a long-term research strand. During the present lecture I will introduce selected case-studies representing the milestones towards the target objectives, requiring the exploration of an understanding-generation loop by means of a close integration between neuroscience and robotics. We predicated this pathway through three main research actions. First, the development of tools enabling neuroscientific measurements and analyses of the human somatosensory system, such as mechatronic tactile stimulators suitable for electrophysiological recordings and for behavioural studies with psychophysical methods. Second, the development of a biomimetic artificial touch technology to code tactile information in a neuromorphic fashion, i.e. with sequences of spikes, and its integration in the distal phalanx of underactuated robotic hands, so to allow its experimental assessment under both passive-touch and active-touch motion control strategies and to evaluate neuroscientific hypotheses on the human somatosensory system. Third, the porting of the developed artificial tactile sensing technology to the afferent pathways of the amputee. This session will discuss recent updates on robotic artifacts and neural information encoding-decoding methods to restore motor and sensory functions and representing a class of neuroprosthetic devices that address sensory-motor integration.

Symposium D: **THE FORGOTTEN DIMENSION IN MULTISENSORY RESEARCH**

Monday 15th June – Fermi Meeting Room 9.00 – 11.00 am

SD.0 Introduction

Nathan van der Stoep{1}, Charles Spence{2}

{1} Utrecht University, Department of Experimental Psychology, Helmholtz Institute, Utrecht, The Netherlands, {2} Oxford University, Department of Experimental Psychology, Oxford, United Kingdom

Given the abundant multisensory information that is presented to us from various distances in both front and rear space, it is surprising to realize how few of the studies of multisensory interactions/integration have incorporated the distance from the observer at which this information was presented into the design of their studies. Taking depth into account is particularly important given that the strength of multisensory interactions depends on the inputs from the different senses involved, which, in turn, vary as a function of the sensitivity of peripheral receptors in the depth dimension (e.g., touch is limited to skin contact, vision and audition extend to far stimuli). Investigating how multisensory stimuli interact in depth is also particularly important to understand how space is represented, as the brain forms multiple representations of space, varying in their extension from the body of the perceiver.

SD.1 LOOKING BEYOND THE HORIZON OF AUDIOVISUAL SIMULTANEITY

Massimiliano di Luca

School of Psychology, CNCR, Birmingham University, United Kingdom.

This symposium will highlight the latest behavioral, neuroimaging, and neuropsychological research on how the relative depth from which sensory cues are presented affects the interactions taking place between the senses. The goal of the symposium will be to highlight the relevance of knowledge about multisensory interactions in depth both for understanding the basic mechanisms of multisensory integration and space representation.

SD.2 MULTISENSORY INTERACTIONS IN PERIPERSONAL SPACE

Andrea Serino

Center for Neuroprosthetics, EPFL, Lausanne, Switzerland

The space immediately surrounding the body, i.e., peripersonal space (PPS), is represented by a dedicated neural system of fronto-parietal areas, which integrate tactile, auditory, and visual stimuli presented on, or close to, the body. In this talk, I will present the first complete mapping of peripersonal space representations around different body parts – namely, the face, the hand and the trunk - in humans. Our latest findings show that these body-part centered PPS representations, although differing in extension and response properties, are not fully independent from each other, but are referenced to the more common reference frame of the trunk. In this talk, I want to argue that different PPS representations have different functions. The peri-hand space is mainly involved in hand-objects interactions: it is represented by premotor and parietal areas, which not only integrate multisensory stimuli around the hand, but also project to the motor system in order to trigger appropriate responses. The peri-hand space also dynamically shapes as a function of changes in upper limb function or structure, such as after after tool-use, amputation, prosthesis implantation and immobilization. The peri-face space is more involved in social interactions, as its boundaries are sensitive to the presence of, and interaction with, other people. Finally, the peri-trunk space serves as a global representation of the whole-body in space, as it includes the other body-parts centered PPSs and shapes during whole body movements (e.g., walking). I will conclude by proposing that the whole-body PPS represents a primary interface between the self and the environment.

SD.3 MULTISENSORY INTERACTIONS IN THE DEPTH PLANE IN FRONT AND REAR SPACE

Nathan van der Stoep

Utrecht University, Department of Experimental Psychology, Helmholtz Institute, Utrecht, The Netherlands

Over the last couple of decades, much has been learned about the nature of multisensory interactions. Among other things, it has been shown that multisensory processing is (un)affected by, for example, the particular spatial and/or temporal alignment of stimuli, stimulus intensity, attention, semantic congruency, and so on. However, one factor that has often been ignored in multisensory research is the distance, or depth, from which stimuli are presented (with the exception of several studies of multisensory temporal processing in depth; see earlier talk by di Luca). In this talk, I will discuss several recent studies of crossmodal spatial attention and multisensory integration in healthy subjects and stroke patients in which the stimuli were presented from different depths in front and/or rear space. The results of these studies indicate that the distance from which information is presented can modulate multisensory interactions. Critically, this modulation depends on the particular sensory modalities involved. Whereas multisensory interactions involving touch are generally more pronounced closer to the body, no such asymmetry in terms of a depth-dependent enhancement is observed for audiovisual interactions. The potential role for multisensory experience in depth in the development of distance-dependent multisensory interactions will be highlighted. Understanding the constraints on multisensory interactions in depth is highly relevant for more applied situations such as the rehabilitation of sensory deficits and multisensory warning signals during driving.

SD.4 DRIVING HAND-OBJECTS INTERACTIONS IN DEPTH BY ANTICIPATED WEIGHTING OF VISUO-TACTILE PROCESSING

Alessandro Farnè

Neuroscience Research Centre of Lyon – CRNL, ImpAct team, Lyon – France

Voluntary actions require preparation of the upcoming movements. Such motor planning is typically accompanied by suppression of peripheral sensation. Here we report that preparing an action to grasp an object instead enhances multisensory processing in depth, as indicated by a remapping of the target closer to the hand well before the hand moves. In a first experiment, we assessed both unisensory tactile perception on the hand and multisensory perception of the same touches in combination with irrelevant visual distractors on the target object during the execution of grasping movements. Visual distractors affected perception of touches more strongly during the planning phase than during a similar, static, object vision condition. Crucially, visuo-tactile (VT) interaction was enhanced in proximity to the onset of the action in the absence of any overt movement, showing both interference and facilitation with respect to previously occurring VT stimulation. Thus, dynamic VT processes lead, rather than follow movement execution. A second experiment tested whether anticipated modulation of VT processing depends upon the final goal of the action, or its sub-goals. We probed VT processing during planning and execution of two-step sequential actions, namely during reach-to-grasp movements and when bringing an object to the mouth. The results supported the hypothesis that VT weighting processes anticipate the final aim of a complex action. These findings reveal that planning to grasp an object entails a multisensory link between signals from the environment and the body that is functionally related to the action goal. Such multisensory planning may thus reflect early sensorimotor transformations aimed at guiding voluntary actions.

Symposium E: **MULTISENSORY INTEGRATION IN SELF-MOTION PERCEPTION**

Monday 15th June – Pacinotti Meeting Room 3.00 – 5.00 pm

SE.0 Introduction

Mark W. Greenlee

Institute for Experimental Psychology, University of Regensburg, Regensburg, Germany

Self-motion perception involves the integration of visual, vestibular, somatosensory and motor signals. This symposium will bring together experts in the areas of single-unit electrophysiology, functional and structural magnetic resonance imaging, electroencephalography and psychophysics to present an update on how the primate brain integrates multisensory information to estimate one's position and motion in space.

SE.1 SELF-MOTION PERCEPTION AND VISUO-VESTIBULAR-SOMATOSENSORY INTERACTIONS

Mariia Kaliuzhna

Center for Neuroprosthetics, Laboratory of Cognitive Neuroscience, Brain Mind Institute, School of Life Science, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Self-motion is encoded by the vestibular system and combines with other sensory cues, such as vision and somatosensation. Although extensively studied in mammals, the mechanisms of vestibular and multisensory self-motion perception in humans remain underexplored, likely due to the technical challenge of measuring brain activity during natural vestibular stimulation. I will first describe a series of behavioural studies exploring visuo-vestibular self-motion perception. Our work shows that visual and vestibular cues signalling passive whole-body rotation are optimally integrated in healthy volunteers. We further demonstrate that conflicting visuo-vestibular stimuli indicating rotation around different axes are also integrated optimally. Such integration is absent in a patient with peripheral vestibular dysfunction associated with illusory own body perceptions (out-of-body experiences). Next, I will describe two studies demonstrating that passive self-rotation (vestibular stimulation) modulates tactile sensitivity and that this effect of vestibular stimulation on touch is modulated by perceived self-motion, as provided by a combined visuo-vestibular percept and not by the visual and vestibular cues independently. These data show that visual and vestibular cues are first combined, producing a self-motion percept that will define the degree of somatosensory modulation. I will conclude by summarising these data and by describing a new research platform allowing to record high-density EEG data during passive self-rotation and concomitant somatosensory and visual stimulation.

SE.2 PERISACCADIC CHANGES IN PERCEIVED HEADING AND THEIR NEURAL CORRELATES

Jan Churan

Philipps University Marburg FB 13 Neurophysics Karl-von-Frisch-Str. 8a 35032 Marburg, Germany

The patterns of optic-flow seen during self-motion can be used to determine the direction of one's own heading. Eye movements challenge this task since they add further retinal image motion and (predictably) distort the retinal flow pattern. In two recent neurophysiological studies we could show that the tuning for heading direction in macaque areas MST and VIP is invariant with respect to tracking eye movements. In a follow-up study, we aimed to decode self-motion direction from population discharges of both areas. Heading could be decoded veridically during steady fixation and during tracking eye-movements. During saccades, however, decoded heading was compressed towards straight-ahead. Given that the functional equivalents of macaque areas MST and VIP have been identified in humans, we were interested in the question if saccades influence also the perceived heading in human observers. Human subjects were presented brief visual sequences simulating self-motion across a ground-plane in one of five different directions during fixation or perisaccadically. After each trial the subjects had to indicate their perceived heading. During fixation perceived heading was not perfectly veridical but shifted centripetally. In saccade trials performance was very similar to fixation trials for motion onsets long (>100ms) before or after a saccade. Around the time of the saccade, however, perceived heading was strongly compressed towards the straight-ahead direction, being equivalent to a compression of heading space. Precision of behavioral judgments was not modulated perisaccadically. This newly-described perceptual phenomenon could be based on the visual processing in cortical areas being responsive to self-motion information. Supported by DFG-SFB/TRR-135/A2

SE.3 VISUAL-VESTIBULAR INTEGRATION OF SELF-MOTION CUES IN THE POSTERIOR INSULAR CORTEX (PIC)

Mark W. Greenlee

Institute for Experimental Psychology, University of Regensburg, Regensburg, Germany

The cortical vestibular network in humans is located in the region of posterior lateral sulcus. An area that responds to visual motion has been described in this region, referred to as the posterior insular cortex (PIC). We localized PIC using visual motion stimulation in functional magnetic resonance imaging (fMRI) and determined whether PIC also responds to vestibular stimuli (Frank et al., 2014. J. Neurophysiology, 112, 248 ff). We also examined PIC with respect to the integration of visual and vestibular information in self-motion perception. Participants viewed limited-lifetime randomly moving dots in the dark (with 10% left or right coherent direction). Using a custom-built MRI-compatible, micro-pump system, hot (48°), cold (5°), or neutral (32°) water flowed through left and right ear pods leading to differential caloric vestibular stimulation simultaneously with the visual stimulation (Frank & Greenlee, 2014, J. Neurosc. Methods, 235, 208 ff). The BOLD response (3-Tesla Siemens Allegra) was contrasted between two conditions of visual motion (coherent leftwards or rightwards) and three conditions of caloric stimulation (both sides neutral, left hot – right cold, left cold – right hot). Localizer runs with purely (100%) coherent motion vs. static dots were conducted to define visual motion areas like MT, MST and PIC. During each trial, participants indicated the presence or absence of self-motion sensations and, if present, the main direction of the combined visual and vestibular percept. The results indicate that motion direction was reported reliably (70-87% correct) for visual and vestibular stimuli. Increased BOLD activity was observed in posterior insular cortex (including area PIC) when participants reported self motion during vestibular stimulation. PIC responded similarly to different combinations of visual and vestibular motion directions. Therefore, area PIC appears to be part of the cortical vestibular network and plays a role in the integration of visual and vestibular stimuli for the perception of self motion.

SE.4 VESTIBULAR-MOTOR INTEGRATION DURING SELF-MOTION PERCEPTION

Paul R. MacNeilage

German Center for Vertigo, University Hospital of Munich, LMU

Vestibular perception has been most often measured in response to passive (externally generated) stimulation. In addition, if the eyes are open, subjects are most often asked to fixate a centrally located fixation point. These manipulations have allowed for well-controlled measurement of vestibular perceptual function. However, during natural behavior vestibular signals are often accompanied by correlated oculomotor and neck motor signals, which provide complimentary information about how the head is moving through space. For example, as we move through the world we usually move our eyes to maintain fixation on objects of interest. The consequences of these fixation eye movements for self-motion perception remain unclear. To investigate this question, we compared perceived displacement across world-fixed, body-fixed and free fixation conditions. Displacement was underestimated in the body-fixed condition, in which the eyes remain stationary, compared to the world-fixed condition, in which the observer must move the eyes to maintain fixation. Both eye movements and perception were intermediate during free fixation. Ultimately, perceived self-motion was well-predicted by a model which gives ~20% weight to the oculomotor estimate of self-motion, i.e. the self-motion consistent with fixation of a world-fixed target. A second study compared perceived head rotation across conditions in which the head movement was generated actively or passively. In addition, in a third condition the magnitude of the vestibular signal was manipulated by presenting passive rotation counter to active head movements. Comparison across conditions shows that head movement is underestimated during passive relative to active movements, revealing a contribution of neck motor signals with a weight of ~15%.

SE.5 VISUAL-VESTIBULAR INTERACTIONS IN THE HUMAN CEREBRAL CORTEX STUDIED WITH FMRI

Andy T. Smith

Royal Holloway, University of London, UK

The study of vestibular function with fMRI in humans is severely limited by the need to keep still during scanning. Artificial vestibular stimulation in darkness has been used to identify the cortical sites associated with vestibular function; our work shows that these include human MST (hMST) and the cingulate sulcus visual area (CSv). However when the surroundings are visible during stimulation, the resulting visual-vestibular cue combination is unnatural and unsuited to studying multisensory interactions. To overcome this problem, we have delivered galvanic vestibular stimulation (GVS) in conjunction with a fully controlled visual environment. This necessitated measuring the vestibulo-ocular reflex (VOR) and compensating for its effect on retinal motion. We presented moving visual stimuli that were either congruent with the illusory motion induced by GVS or equal in magnitude but opposite in direction. Vestibular and retinal motion were both sinusoidal (1Hz) and the two conditions used the same retinal and vestibular stimuli, differing only in the relative phase of the two. Various cortical regions that are candidates for visual-vestibular interaction were identified with visual and vestibular localisers. Univariate response magnitude differed little between the two conditions in any of these areas. Multi-voxel pattern analysis was then used to seek evidence of sensitivity to the phase of cue combination (congruent or opposite) in each region. hMST, putative human VIP and a region (PIC) adjacent to parieto-insular vestibular cortex were strongly sensitive to whether the cues were congruent or opposite. Other regions, including V1 and, notably, CSv, were insensitive to this manipulation.

Symposium F: THE CURIOUS INCIDENT OF ATTENTION IN MULTISENSORY INTEGRATION: BOTTOM-UP AND TOP-DOWN

Monday 15th June – Fermi Meeting Room 3.00 – 5.00 pm

SF.0 Introduction

Ruth Adam{1}, Jess Hartcher-O'Brien{2}, Salvador Soto-Faraco{3}

{1} Institute for Stroke and Dementia Research, Ludwig~Maximilian-University, Munich, Germany {2} Sorbonne Universites, UPMC Univ Paris, 06, UMR 7222, ISIR, F---75005 Paris, France {3} ICREA --- Parc Científic de Barcelona & Dept. de Psicologia Bàsica Universitat de Barcelona

The role attention plays in our experience of a coherent, multisensory world is still an object of intense debate. On the one hand, it has been suggested that attention guides MSI in a top-down fashion by selecting specific to-be-integrated inputs. On the other hand, there is evidence that some integration occurs in a bottom-up manner, based on temporal and spatial correlations, independent of the focus of attention. Attention itself is not a unitary construct, and may refer to a range of different selection mechanisms. Therefore, the interplay between attention and MSI can take many forms which in part explains the diversity of findings. This symposium focuses on recent integrative evidence showing how attention and multisensory processing interact, from behavioural, computational, neuropsychological and brain imaging perspectives. The goal is to illustrate the interplay between bottom-up and top-down processes in various multisensory scenarios with the hope of reaching general, evidence based conclusions. The first talk (Krüger) describes psychophysical findings where the context set by the attended motion direction in one sensory modality impacts the perceived location of events in that, and other modalities (top-down). The second talk (Vercillo) combines behavioural and computational approaches to reveal that the interplay between sensory inputs and the top-down role of attention (to sound) shapes MSI (audiotactile) as predicted by the Maximum Likelihood Estimation model. The third talk (Noppeney) reports a pattern classification fMRI experiment showing how relative sensory reliabilities (bottom-up) and task relevance (top-down) play a role when judging the location of a multisensory event in accordance with Bayesian Causal Inference. The following talk (Macaluso) reports neuropsychological evidence for the balance between stimulus salience (bottom-up) and orienting behaviour (top-down) in audiovisual integration. The symposium will conclude with an overview of the role of attention and internal cognitive processes on MSI from a predictive coding perspective (Talsma).

SF.1 MOTION-INDUCED POSITION SHIFTS IN AUDITORY AND VISUAL MODALITIES

Hannah M. Krüger

Laboratoire Psychologie de la Perception, Université Paris Descartes, 45, rue des Saints-Pères, 75006 Paris, France

Motion-induced position shifts (MIPS) are well-studied phenomena in visual perception. These MIPS are easily demonstrated with illusions such as flash-grab, where a flashed object is dragged in the direction of an attended, surrounding motion. Little is known about whether MIPS exist in other modalities and whether a common, possibly attentionbased mechanism could account for it. We asked subjects to judge whether a brief 5ms gap was to the left or right of straight ahead in a sweep of an auditory noise stimulus that moved from right to left (using interaural loudness difference to move the signal location) or vice versa. In line with visual MIPS, subjects persistently judged the location of these stimuli as occurring further in direction of the motion than its veridical location. Similarly, the same subjects also judged a brief change to a moving visual stimulus as occurring further in direction of the motion. This finding shows that motion, regardless of the modality in which it is presented, can give rise to MIPS and potentially points towards a common mechanism.

SF.2 ATTENTION TO SOUND IMPROVES AUDITORY RELIABILITY IN AUDIO-TACTILE SPATIAL OPTIMAL INTEGRATION

Tiziana Vercillo

Robotics, Brain & Cognitive Sciences Department, Fondazione Istituto Italiano di Tecnologia, via Morego 30, 16163 Genoa, Italy

Humans integrate multisensory signals in an optimal fashion. It is still unclear, however, whether or not attended stimuli are integrated differently from those that are not attended. Here we investigated the impact of attention in audio-tactile optimal integration. We tested participants in an attentional condition with a dual task paradigm and in a non-attentional condition. Three unisensory or multisensory stimuli, conflictual or not conflictual sounds and vibrations arranged along the horizontal axis, were presented sequentially. In the primary task participants had to evaluate the spatial position of the second auditory stimulus (the probe) with respect to the others (the standards). In in the secondary task they had to report occasionally changes in duration of the auditory probe stimulus. In the non-attentional condition participants only performed the primary task. We used the Maximum Likelihood Estimation (MLE) model to predict audio-tactile spatial localization. Our results showed enhanced auditory precision (and auditory weights) in the attentional condition with respect to the control non-attentional condition. Interestingly in both conditions the audio-tactile interaction was well predicted by the MLE model. The results of this study support the idea that modality-specific attention modulates multisensory integration.

SF.3 MULTISENSORY SPATIAL PRIORITY MAPS IN PARIETAL CORTEX

Uta Noppeney

Computational Neuroscience and Cognitive Robotics Centre, University of Birmingham, UK

For effective and fast interactions with our natural environment the brain needs to form spatial priority maps that code the importance of locations based on bottom-up input salience and top-down task-goals. Despite numerous neuroimaging studies of visual spatial attention, it is unknown how the brain forms spatial priority maps that enable interacting with our complex multisensory world. This functional magnetic resonance imaging study presented participants with audiovisual signals while manipulating their sensory reliability, task-relevance / modality-specific attention (i.e., visual vs. auditory report) and spatial discrepancy. Using multivariate decoding we characterized the spatial representations that were formed along the auditory and visual processing hierarchies. Our results suggest that parietal cortices (IPS3/4) integrate auditory and visual signals weighted by their bottom-up relative sensory reliabilitiesand top-down task relevance into multisensory spatial priority maps. Critically, in line with the principles of Bayesian Causal Inference these spatial priority maps take into account the causal structure of the world. Multisensory priority maps go functionally beyond traditional unisensory spatial priority maps by coding spatial priority based on signals from multiple sensory modalities, their relative reliabilities and task-relevance. They thus enable us to attend and respond rapidly to important events in our complex multisensory environment.

SF.4 CROSSMODAL SPATIAL INTERACTIONS IN NATURALISTIC ENVIRONMENTS: BEHAVIOUS, FUNCTIONAL IMAGING AND BRAIN-LESION DATA

Emiliano Macaluso

Neuroimaging Laboratory, Fondazione Santa Lucia, Rome, Italy

Crossmodal interactions are thought to be pervasive in everyday life, but the vast majority of previous studies about not-linguistic audiovisual processing employed simple, artificial and stereotyped stimuli (e.g. flashes of light and bursts of white noise). Here, we will present a set of studies that instead made use of rich and dynamic stimuli to investigate audiovisual spatial interactions in more realistic experimental settings. We combined eye-movement recordings, computational models of visual and auditory saliency, functional imaging and lesion mapping in neglect patients to characterise audiovisual interactions during spatial orienting. Behaviourally, we found that visual events tend to dominate eyemovement behaviour, with a further contribution of bottom-up visual saliency. Nonetheless, functional imaging results revealed spatial interactions between visual and auditory signals in the posterior parietal cortex, where activity increased for spatially-congruent, salient audiovisual events. These spatial interactions were further modulated according to orienting behaviour, thus reflecting the efficacy of the audiovisual events for spatial orienting rather than just indexing some sensory response to congruent audiovisual input. Eye-movements data in neglect patients, with lesioned inferior fronto-parietal areas but intact posterior parietal cortex, revealed the expected spatial bias towards the right hemifield, but also that the effect of audiovisual spatial congruence was preserved. The latter confirmed the central role of the dorsal parietal cortex for the integration of audiovisual spatial signals during orienting. We propose that audiovisual spatial interactions generate processingpriority signals within the posterior parietal cortex, and that these contribute to guide attentional selection and overt orienting behaviour in complex multisensory environments.

SF.5 AN ATTENTIONAL ACCOUNT OF THE MULTISENSORY MIND

Durk Talsma

Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, B- 9000 Ghent, Belgium

Multisensory integration involves a host of different cognitive processes, occurring at different stages of sensory processing. Here I argue that, despite recent insights suggesting that multisensory interactions can occur at very early latencies, the actual integration of individual sensory traces into an internally consistent mental representation is dependent on both top-down and bottom-up processes. Moreover, I argue that this integration is not limited to just sensory inputs, but that internal cognitive processes also shape the resulting mental representation. Recent studies providing evidence for this notion will be discussed. Studies showing that memory recall is affected by the initial multisensory context in which the stimuli were presented will be discussed, as well as several studies showing that mental imagery can affect multisensory illusions. This empirical evidence will be discussed from a predictive coding perspective, in which a central top-down attentional process is proposed to play a central role in coordinating the integration of all these inputs into a coherent mental representation.

Symposium G: **BRAIN OSCILLATIONS IN MULTISENSORY INTEGRATION**

Tuesday 15^{tn} June – Pacinotti Meeting Room 9.00 – 11.00 am

SG.0 Introduction

Vincenzo Romei{1}, Marcello Costantini{2}

{1} Department of Psychology, University of Essex, {2} Department of Neuroscience and Imaging, University of Chieti

Recent years have seen an emerging interest in the role that brain oscillations may play in guiding, binding and deciphering sensory information. While initially explored within each sensory modality, oscillatory activity has provided a unique neurophysiological framework able to better understand how our senses are integrated and interact in space and time. A wealth of recent exciting studies has provided novel insights and opened new challenging questions on how brain oscillatory activity: (i) bind information from different sensory modalities (ii) connect crossmodal and multisensory processes to attention mechanisms (iii) drive multisensory processes via modulation of inhibitory and excitatory neurotransmitters. The aim of this symposium is to provide the most recent evidence from behavioural, neuroimaging, electrophysiological and neurochemical studies trying to answer these questions. Christoph Kayser will present behavioural and EEG evidence suggesting that some of the 'early' multisensory perceptual interactions can in fact be explained based on attention-related processes. Tony Ro will present studies showing the impact of prestimulus EEG alpha amplitude and phase on visual and tactile detection. Marcello Costantini will present EEG evidence showing that spontaneous brain activity can reliably predict the individual's Temporal Binding Window. Markus J. Van Ackeren will present MEG and sEEG evidence showing how multisensory integration arises from neuronal interactions within and across different levels of the cortical hierarchy. Finally, Daniel Senkowski will highlight a three-fold relationship between GABA, brain oscillatory activity and multisensory integration. Overall the symposium will present an overview of the state-of-the-art research in the neural oscillatory mechanisms subtending multisensory processes in the adult human brain.

SG.1 WHEN SOUNDS AND SIGHTS INFORM EACH OTHER - FROM EARLY TO LATE MULTISENSORY INTERACTIONS

Christoph Kayser

Institute of Neuroscience and Psychology, Glasgow University

Considerable work has focused on so early multisensory interactions. As such one considers multisensory processes whereby stimuli in the different modalities interact at early stages of the respective pathways, or do so in seemingly automatic fashion independent of cognitive processes. Thereby it is often the case that one modality modulates the processing within another, but does not provide highly specific sensory information (in contrast to feature-integration). There are many behavioural paradigms in which multisensory perceptual benefits have been considered to arise from such early interactions. Yet it remains unclear whether the observed perceptual effects are indeed explained by anatomical or physiological processes that fit the definition of early. I will present work from behavioural and neuroimaging experiments that suggests that some of the previously reported 'early' multisensory perceptual interactions can in fact be explained based on attention-related processes. In a behavioural paradigm auxiliary and task-irrelevant sounds enhanced subject's performance in a visual task. EEG recordings showed that in perceptual multisensory benefits were best explained by parieto-occipital alpha band oscillatory activity rather than e.g. the specific enhancement of early visual components. Given that alpha-band activity has been closely linked to attention, it may be that multisensory benefits in these paradigms arise from a multisensory effect on attention rather than direct sensory interactions. Disentangling the contributions of automatic attentional deployment and other multisensory interactions will be a challenge for future studies.

SG.2 THE ROLE OF PRESTIMULUS ALPHA OSCILLATIONS IN VISUAL AND TACTILE PERCEPTION

Tony Ro

Department of Psychology, The City College of the City University of New York

When interacting with our environments, we typically rely on more than one sensory modality to accomplish a given behavior. For example, when attempting to pick out a ripe peach from a bowl, how the fruit both looks and feels can provide useful information about its ripeness. Because in such circumstances we must use information from different sensory modalities to accomplish a common goal, we might expect similar neural mechanisms that may be encoding information from the different sensory modalities. In this talk, I will review recent studies that we have been conducting that show systematic influences of vision on touch perception, similar prestimulus EEG alpha amplitude and phase effects on visual and tactile detection, and how neural responses to information from one sensory modality may influence the processing of information from a different sensory modality. Together, these studies shed some light on how information from the different sensory modalities may be coordinated for successful behavior.

SG.3 MULTISENSORY TEMPORAL BINDING WINDOW AND ONGOING BRAIN ACTIVITY: ARE THEY RELATED?

Marcello Costantini

Department of Neuroscience and Imaging, University of Chieti

Multisensory integration depends heavily on the temporal relationship of the different sensory inputs, known as – the temporal rule. Multisensory integration, indeed, occurs within a limited range of delays. This temporal range is known as Temporal Binding Window. This window is not only conceptually relevant, but seems to be altered in clinical conditions including schizophrenia and autism spectrum disorders. In this talk I will look at the neural markers of the Temporal Binding Window. It is now well established that the brain never rests. Such ongoing activity, and its variability, deeply impact on the conscious awareness of unisensory and multisensory stimuli

in the environment as well as on their evoked-related neural activity. In this talk I will provide EEG evidence showing that the brain ongoing activity, in particular the phase of alpha rhythm can reliably predict the individual's Temporal Binding Windows.

SG.4 INDENTIFYING OBJECTIVE MEASURES OF MULTISENSORY INTEGRATION IN SPACE AND TIME

Markus J. van Ackeren

CiMEC, University of Trento, Italy

When it comes to temporal judgments humans rely more on audition than on any other sensory modality. For instance, some multisensory illusions (e.g., flicker-flutter and double flash) compellingly illustrate how the auditory system can modulate the conscious perception of visual events. Multisensory integration (MSI) has been suggested to arise at every level of the cortical hierarchy. However, defining an objective measure of MSI in space and time has been a challenge. In our lab, we rely on magnetoencephalography (MEG) as well as stereoelectroencephalography (sEEG) recordings from surgically implanted electrodes in patients with epilepsy to deconstruct how MSI arises from neuronal interactions within and across different levels of the cortical hierarchy. First, we developed an original steady-state paradigm using the well known auditory capture of visual time to objectively measure MSI. Second, using the unequalled spatial and temporal resolution of sEEG, we investigate if, and how, MSI is implemented in low-level auditory and visual cortices.

SG.5 RESTING GABA CONCENTRATION IN THE SUPERIOR TEMPORAL GYRUS PREDICTS GAMMA BAND OSCILLATIONS AND MULTISENSORY PERCEPTION

Daniel Senkowski

Department of Psychiatry and Psychotherapy, Charité Berlin

A few years ago, we hypothesized that gamma band oscillations play an important role in multisensory perception (Senkowski et al. 2008, Trends Neurosci). However, evidence for this proposal is still sparse. Moreover, there is an ongoing debate as to whether resting GABA concentration in humans, as obtained by magnetic resonance spectroscopy, predicts gamma band activity. In this talk I will present data from a combined MRS-EEG study examining 41 participants. We investigated the relationships between GABA concentration in the left superior temporal gyrus (STG), source localized gamma band activity in the sound-induced flash illusion, and illusion rate in this multisensory paradigm. The study revealed highly significant positive relationships (r-values = .42 to .53) between the three measures. Using path modeling we found that GABA concentration in the STG mediated the positive relationship between gamma band power and multisensory perception. Underscoring the crucial role of neural oscillations in multisensory processing, our study provides first evidence for a three-fold relationship between GABA, gamma band oscillations and multisensory perception.

Symposium H: **MULTIMODAL CONTRIBUTIONS TO BODY REPRESENTATION**

Tuesday 15th June – Fermi Meeting Room 9.00 – 11.00 am

SH.0 Introduction

Matthew R. Longo

Department of Psychological Sciences, Birkbeck, University of London, London, UK

Our body is a unique entity by which we interact with the external world. Consequently the way we represent our body has profound implications in the way we process and locate sensations and in turn perform appropriate actions. The body can be the subject, but also the object of our experience, providing information from sensations on the body surface and viscera, but also knowledge of the body as a physical object. However, the extent to which different senses contribute to constructing the rich and unified body representations we all experience remains unclear. With this symposium we aim to bring together recent research showing important roles for several different sensory modalities in constructing body representations. At the same time, we expect to generate new ideas of how and at which level the senses contribute to generate the different levels of body representations and how they interact. Before commencing, we will give a brief overview of the most recent research on body representation focusing on different sensory domains. Prof Angelo Maravita (University of Milano Bicocca) will present neuropsychological evidences about multisensory control of pain. We will then discuss in healthy individuals how visual (Dr Sally Linkenauger, Lancaster University), auditory (Dr Ana Tajadura, University College London), vestibular (Dr Elisa Ferre, University College London) and tactile (Prof Matthew Longo, Birkbeck, University of London) systems can affect the representations of our body. Finally, we will comments and give a final remarks.

SH.1 MULTISENSORY PROCESSING OF NOXIOUS STIMULI IN THE NORMAL AND DAMAGED BRAIN

Angelo Maravita

Department of Psychology, University of Milano-Bicocca, Milano, Italy

Pain experience has recently shown to be strictly influenced by the ongoing representation of the body, which is constantly updated through multiple sensory modalities. In particular, vision of the body has shown to critically modulate pain experience in both chronic and acute pain situations. I will present results from recent experiments showing that the vision of a body part receiving an acute noxious stimulation produces an initial increase in arousal response (as measured by skin conductance response) when the stimulus approaches the body, followed by decreased response once the stimulus contacts the skin. Such evidence may be compatible with the activation, through vision, of descending analgesic pathways that contrast incoming noxious afference, with a consequent reduction of sensory response on stimulus contact. Furthermore, I will show that in patients presenting with unilateral loss of ownership towards their own limbs following brain damage, a condition known as somatoparaphrenia, when a noxious stimulus approaches the affected arm, no anticipatory response is observed, while this is still present when the stimulus is directed towards the unaffected arm. This is in line with the idea that body ownership and sensory experience are strictly linked. From the above evidence it can be argued that a multi-level processing of noxious stimuli occurs along the sensory systems and that different processes, such as multisensory integration and body ownership, critically affect body/space interactions and the features of pain experience.

SH.2 THE VISUAL PERCEPTION OF RELATIVE BODY PROPORTIONS

Sally A. Linkenauger

Department of Psychology Lancaster University, Lancaster, UK

Individuals have a generous amount of visual information, which specifies the relative proportions of their bodies. Nevertheless, across a multitude of studies, we have discovered large distortions in the visual perception of the relative lengths of individuals' bodily proportions. These distortions vary indirectly with the size of the body part's representation on the somatosensory cortex. These distortions persist when individuals view their bodies in a mirror as well as when viewing the relative proportions of other people's bodies. Although perceived relative body part length shows these distortions, relative body widths are perceived quite accurately. We have evidence suggesting that the origin of these distortions may be a result of a compensatory mechanism to achieve tactile constancy despite differences in tactile receptive field sizes across body parts.

SH.3 THE HEARING BODY: INFLUENCES OF AUDITION ON BODY REPRESENTATIONS

Ana Tajadura-Jiménez

UCL Interaction Centre (UCLIC) University College London, London, UK

Awareness of our physical body is a key component in our sense of who we are and for our interactions with others and the world. Importantly, whereas the size of our actual body does not change suddenly, the mental body representations we have of our body are not fixed but are continuously updated through the sensory cues received from the environment. The role of audition in forming these body representations has received less attention than that of other modalities. In this talk, I will present evidences from our recent research showing that the sounds that accompany almost every of our bodily movements and actions are used to form these representations. These action sounds are highly rich in information about one's body. For instance, the sounds produced when tapping on a surface inform us about the length and strength of our arm. Our results have revealed that the altering of action sounds impacts body representation. In particular, we have collected evidence of auditory-driven changes in the mentally represented length of one's own arm, as well as in the represented height and width of one's own body. Our studies have also shown that these auditory-driven changes in body-representation are connected to effects in motor behaviour and emotional state. These results provide evidence of an auditory-dependent plasticity of body-representation.

SH.4 VESTIBULAR CONTRIBUTION TO SELF-REPRESENTATION

Elisa Raffaella Ferrè

Institute Congitive Neuroscience (ICN) University College London, London, UK

The vestibular system provides an absolute gravitational reference for control of body posture in space. Information from the vestibular organs is integrated with other sensory signals. Multimodal convergence has been described in almost all vestibular relays, including the vestibular nuclei, the thalamus and several areas in the cerebral cortex. Using established techniques for artificially stimulating the vestibular system in healthy participants, we showed that vestibular inputs improve detection of faint touch stimuli delivered to the hand. Interestingly, vestibular stimulation has opposite effects on different somatosensory sub-modalities (pain). This vestibular rebalancing

between senses may be a crucial element of the brain's capacity to create a coherent body representation. To investigate this hypothesis we combined vestibular stimulation with a multimodal model of bodily awareness (Rubber Hand Illusion - RHI). Vestibular signals influence the multisensory weighting functions that underlie RHI: the right hemisphere vestibular projections activated by the vestibular stimulation increased the weight of intrinsic somatosensory and proprioceptive signals about hand position, and decreased the weight of visual information responsible for visual capture during the RHI. Vestibular signals are not only an input for motor control and postural responses: here we provide a behavioural demonstration that vestibular signals contribute to bodily awareness. We argue that vestibular inputs modulate the weighting of intrinsic somatosensory and proprioceptive signals in the process of multisensory integration of information about the body.

SH.5 MAPPING BODILY SPACE WITH TOUCH

Matthew R. Longo

Department of Psychological Sciences, Birkbeck, University of London, London, UK

The skin is physically co-extensive with the external surface of the body. As the skin is also the primary receptor surface for touch, this creates an intimate connection between touch and the size and shape of the body. Since Weber's seminal contributions in the 19th century, it has been known that perceived tactile distances are systematically related to tactile sensitivity, being expanded on sensitive skin surfaces compared to less sensitive surfaces. More recent studies have found that tactile distance is also modulated by higher-level representations of body size and shape. This suggests that tactile distances arise from the interaction of distorted somatosensory maps and (presumably more veridical) abstract body representations. In this talk, I will describe a series of studies investigating distortions of tactile distance perception. These studies focused in particular on whether the distortions can be characterised as a geometrically simple "stretch" applied to the representation of bodily space. In a first series of experiments, we show that the pattern of perceived tactile distance across several orientations is consistent with a simple stretch. In a second set of experiments, we use multidimensional scaling to directly reconstruct the geometric structure of tactile space, again showing that it can be effectively modelled as a simple stretch of actual skin space. Together, these studies suggest that the large distortions of perceived tactile distance can be interpreted in terms of a geometrically simple stretch of the mediolateral axis of the limbs.

Symposium I: **ABOVE THE MEAN-EXAMINING VARIABILITY IN MULTISENSORY PROCESSING**

Tuesday 15th June – Pacinotti Meeting Room 3.00 – 5.00 pm

SI.0 Introduction

Sarah H. Baum, Mark Wallace

Vanderbilt Brain Institute, Vanderbilt University, Nashville, TN, USA

It is well known that behavioral, perceptual, and neural responses vary from trial-to-trial, even when the stimuli and task are highly controlled. Under typical circumstances, this variability is purposefully reduced through data processing, averaging across trials and across subjects to reveal some overarching pattern in responses. However, emerging work suggests that this variability (both across individuals and across trials within an individual participant) may actually provide powerful clues into brain and behavior. The goal of the symposium is to shed light on possible functional roles of variability in multisensory processing, both as it relates to inter- and intraindividual differences. What leads to a higher degree of multisensory enhancement in some individuals as opposed to others? Why does the reaction time to a multisensory stimulus beat the race model on some trials but not others? We have gathered a group of young and established investigators who represent a wide array of experimental techniques and perspectives to present and discuss the influence of variability in behavioral and neural responses. In particular we aim to address the ways in which variability might confer adaptive or maladaptive effects, and the array of analytical techniques that can shed light on this emerging area of studying variability in multisensory processing.

SI.1 ABOVE THE MEAN - EXAMINING VARIABILITY IN MULTISENSORY PROCESSING

Mark Wallace

Vanderbilt Brain Institute, Vanderbilt University, Nashville, TN, USA;

It is well known that behavioral, perceptual, and neural responses vary from trial-to-trial, even when the stimuli and task are highly controlled. Under typical circumstances, this variability is purposefully reduced through data processing, averaging across trials and across subjects to reveal some overarching pattern in responses. However, emerging work suggests that this variability (both across individuals and across trials within an individual participant) may actually provide powerful clues into brain and behavior. The goal of the symposium is to shed light on possible functional roles of variability in multisensory processing, both as it relates to inter- and

intraindividual differences. What leads to a higher degree of multisensory enhancement in some individuals as opposed to others? Why does the reaction time to a multisensory stimulus beat the race model on some trials but not others? We have gathered a group of young and established investigators who represent a wide array of experimental techniques and perspectives to present and discuss the influence of variability in behavioral and neural responses. In particular we aim to address the ways in which variability might confer adaptive or maladaptive effects, and the array of analytical techniques that can shed light on this emerging area of studying variability in multisensory processing.

SI.2 INTRA-INDIVIDUAL VARIABILITY IN BEHAVIORAL AND NEURAL RESPONSES TO SIMPLE AUDIOVISUAL TARGET DETECTION

Sarah Baum

Vanderbilt Brain Institute, Vanderbilt University, Nashville, TN, USA;

Inconsistency in reaction time (RT) is considered a classical marker of intra-individual variability and has been used in a number of studies as an indicator or predictor of future cognitive decline. Moreover, increases in neural variability have also been observed across a number of experimental techniques in both healthy older adults and clinical populations. The purpose of this study was to investigate how behavioral variability and neural variability are related within individual subjects in a multisensory context. Although it makes intuitive sense that increased behavioral variability might be associated with increased neural variability (thus reflecting what has been termed high sensory noise), this link has not been systematically investigated within the same subjects. We conducted a functional magnetic resonance imaging (fMRI) experiment with healthy young adults using a simple target detection task with unisensory (auditory and visual) and multisensory (audiovisual) conditions where the efficacy of both the auditory and visual components was varied. We will discuss how individual differences in both the mean and standard deviation of the RT in each condition might be related to multisensory enhancement as well as changes in the mean and standard deviation of the evoked neural (blood oxygen level dependent, BOLD) response. Furthermore, we will present both a region of interest (ROI) based approach and a whole-brain approach, showing how these findings might affected by analytical choices.

SI.3 RESPONSE TIME VARIABILITY UNDER CROSSMODAL STIMULATION: EFFECTS OF A TIME WINDOW OF INTEGRATION

Hans Colonius

Department of Psychology, University of Oldenburg, Oldenburg, Germany

Trial-to-trial variability is an inherent feature of behavioral responses and the principal reason to conceive of reaction time (RT) as a random variable. While RT variance (or standard deviation) is routinely reported as a descriptive measure, its theoretical status has not been studied intensively. Here, within the context of the temporal window of integration concept, we investigate the sources of RT variability in the crossmodal condition and how crossmodal variability compares to unimodal variability. We show that crossmodal RT variance can be decomposed into several additive components by conditioning on the event of integration either occurring or not occurring in a given response trial. We find that the covariance between first and second stage processing times can be positive, negative, or zero depending on how the event of integration affects average processing time in both the first and second stage. We reveal a necessary condition for crossmodal variance to be strictly smaller than unimodal variance. Even without adopting a parametric model, like the ex-Gaussian, stringent tests of the time window hypothesis can be derived from these results, as soon as certain auxiliary assumptions are made about how experimentally controlled variables affect the model parameters.

SI.4 NOBODY'S PERFECT. TRACKING THE IMPERFECTIONS IN AUDIOVISUAL INTEGRATION

Antonia Thelen

Vanderbilt Brain Institute, Vanderbilt University, Nashville, TN, USA;

Multisensory facilitation of behavioral and neuronal responses has been extensively demonstrated over the past decades. Nonetheless, these reports have typically reported effects observed across participants and trials. More recently, evidence has started to accumulate that suggests substantial between--- and within---subject variability in the processing of auditory---visual information. Importantly, these findings are by no means circumscribed to specific contexts; rather, the variability in multisensory processing has been demonstrated across a wide range of perceptual tasks and stimulus types/ combinations. This points to the fundamental question of the nature of the mechanisms that underlie this variability, and ultimately that relate to the efficacy of multisensory processes. I will present behavioral and electrophysiological (EEG) data from simple and motion detection tasks using stimuli of varying degrees of effectiveness ranging from suprathreshold to perithreshold. Analyses are focused on distilling the differences that are responsible for the presence of multisensory facilitation on some trials versus its absence on others. The aim of our investigations is to understand the neural networks underpinning early, perceptual processing stages of multisensory events, and to quantify the mechanistic differences that determine both between---subject and between---trial variability observed at the behavioral level.

SI.5 VARIABILITY OF SPEECH ACOUSTIC FEATURES AND THEIR REPRESENTATION IN SUPERIOR TEMPORAL CORTEX

Cristiano Micheli

Department of Psychology, Carl-von-Ossietzky University, Oldenburg, Germany

Recent studies have related speech acoustic parameters to neural responses (Pasley et al. 2012). However, it is unclear how visual speech alters speech acoustic representations in early and higher auditory areas. The aim was to determine which brain regions respond to which speech acoustic features and whether vision alters these representations. A variable speech stimulus set was used to optimally extract spectro---temporal tuning. We presented 210 different audiovisual (AV) and auditory (A) sentences to 6 patients implanted with subdural electrodes (ECoG grids on temporal cortex). We analyzed neural high gamma activity, which has been shown to correlate with neural firing (Ray and Maunsell 2011) and compared responses between conditions. We devised a GLM elastic---net model that relates stimuli features with neural high gamma activity, to estimate spectro---temporal receptive fields (STRFs) for single electrodes and compare estimations between conditions. In early auditoryareas we observed strong high gamma increases with respect to baseline to both AV and A speech, but no differences between conditions. In contrast, posterior superior temporal gyrus (pSTG) showed stronger high gamma increases to AV compared to A speech. STRFs in early auditory areas showed tuning to speech acoustic features across subjects. But no differences in the STRFs were found between AV and A speech in early auditory areas. Our results indicate that visual speech enhances speech responses in pSTG. In early auditory areas, high---gamma responses and acoustic feature representations did not differ between AV and A speech. Next, we will investigate speech specific feature representations in pSTG.

Symposium J: **THE MULTIFACETED INTERPLAY BETWEEN MULTISENSORY INTEGRATION AND CONSCIOUSNESS**

Tuesday 15th June – Fermi Meeting Room 3.00 – 5.00 pm

SJ.0 Introduction

Uta Noppeney

Computational Neuroscience and Cognitive Robotics Centre, University of Birmingham, UK

Information integration has been considered a hallmark of human consciousness. Yet, the complex interdependencies between information integration and consciousness remain to be defined. While perceptual awareness has been traditionally studied in a single sense (e.g. vision), recent years have witnessed a surge of interest in perceptual awareness in the field of multisensory integration.

To which extent can signals from different senses be integrated in the absence of awareness? What sort of perceptual estimates can be biassed by signals that we are not aware of? How can multisensory integration enable the emergence of a unified consciousness? Which experimental paradigms and findings enable us to characterize the limits and prerequisites of multisensory consciousness?

This symposium brings together four speakers that will tackle these issues from complementary experimental and conceptual perspectives. We envisage that the symposium will stir lively discussions and help the multisensory community to advance our understanding of the multifaceted interplay between multisensory integration and consciousness.

SJ.1 MULTISENSORY CONSTRAINTS ON AWARENESS

Ophelia Deroy, Charles Spence

Crossmodal Research Laboratory, Experimental Psychology, Oxford University, UK

Given that multiple senses are often stimulated at the same time, perceptual awareness is most likely to take place in multisensory situations. However, most theories of awareness are based on studies and models established for a single sense (mostly vision). Here, we consider the methodological and theoretical challenges raised by taking a multisensory perspective on perceptual awareness. First, we consider how well tasks designed to study unisensory awareness perform when used in multisensory settings, stressing that studies using binocular rivalry, bistable figure perception, continuous flash suppression, the attentional blink, repetition blindness, and backward masking can demonstrate multisensory influences on unisensory awareness, but fall short of tackling multisensory awareness directly. Studies interested in the latter phenomenon rely on a method of subjective contrast, and can, at best, delineate conditions under which individuals report experiencing a multisensory object or two unisensory objects. As there is not a perfect match between these conditions and those in which multisensory integration and binding occur, the link between awareness and binding advocated for visual information processing needs to be revised for multisensory cases. These challenges point at the need to question the very idea of multisensory awareness.

SJ.2 CROSS-MODAL INTERACTIONS DURING BINOCULAR RIVALRY AND UNDERLYING NEURAL MECHANISMS

Claudia Lunghi

Department of Translational Research on New Technologies in Medicine and Surgery, University of Pisa, Pisa, Italy

The resolution of perceptual ambiguity is one of the main functions of cross-modal interactions. Binocular rivalry is a form of perceptual bistability in which each monocular image is temporarily removed from visual awareness in favour of the other. Here we present psychophysical evidence investigating cross-modal interactions between touch, audition and vision during binocular rivalry. We show that haptic signals interfere with the dynamics of binocular rivalry between oriented gratings by boosting the visual stimulus parallel to the haptic one, both prolonging conscious perception and restoring it from binocular rivalry suppression. This cross-modal interaction occurs both for active exploration and passive tactile stimulation, is strictly tuned (less than one octave) for matched visuo-haptic spatial frequencies and orientations and depends on temporal and spatial proximity between visual and haptic stimuli. Moreover, haptic stimulation prevents the congruent visual stimulus from becoming deeply suppressed reducing binocular rivalry suppression depth by 45%. Taken together, these results point to an early multisensory interaction site, possibly V1. What is the neural mechanism underlying this cross-modal interaction? One possibility is a cross-modal entrainment of neural oscillations resetting visual rivalrous oscillations. We show that auditory and tactile rhythms combine to synchronize vision during binocular rivalry (auditory and tactile too weak on their own to bias rivalry had a strong influence over vision when combined and interleaving tactile and auditory pulses synchronized vision to the combined audio-tactile frequency), suggesting a common neural substrate for auditory and tactile rhythm processing and the existence of a supra-modal temporal binding mechanism.

SJ.3 MULTISENSORY INTEGRATION AND CONSCIOUSNESS: BEYOND CROSS-MODAL PRIMING

Nathan Faivre

Laboratory of Cognitive Neuroscience, Brain Mind Institute, Ecole Polytechnique Fédérale de Lausanne, Switzerland

Perception and action involve multisensory integration, that is the binding of signals from different sensory modalities into unified percepts. The role of perceptual consciousness in this process has been the object of recent empirical investigations, several studies reporting cross-modal priming effects in which the processing of an invisible stimulus biased - or sometimes was biased - by a perceived stimulus in the auditory, tactile, olfactory, or proprioceptive modality. Extending these results, we recently showed that the congruency between digits presented in the auditory and visual modalities can be encoded even when both digits are rendered subliminal by masking. This suggests that cross-modal processing can occur in the complete absence of consciousness (notably, only following conscious training). In light of classical findings in multimodal processing, we will discuss two interpretations of this data. The first is that such unconscious cross-modal effects are driven by multisensory integration, and the second - that they rely on amodal representations at high hierarchical levels. We will present experiments that can test these two interpretations, in order to clarify the interplay between multisensory integration and consciousness.

SJ.4 INTERACTIONS ACROSS THE SENSES IN THE EMERGENCE OF MULTISENSORY CONSCIOUSNESS

Mate Aller

Computational Neuroscience and Cognitive Robotics Centre, University of Birmingham, UK

We have characterized the multifacted interplay between multisensory integration and consciousness from two perspectives: First, we have investigated to which extent sensory signals can be integrated in the absence of awareness? Using continuous dynamic flash suppression we demonstrated bidirectional interactions between unaware visual and aware auditory signals: (i) Aware auditory signals boosted suppressed visual flashes into perceptual awareness depending on spatial congruency. (ii) Conversely, suppressed and unaware flashes biased where participants perceived sounds they were aware of. Second, we have investigated whether multisensory interactions enable the emergence of a unified multisensory consciousness by tracking the perceptual dynamics in vision and touch during multistable motion rivalry. We demonstrate pronounced bidirectional interactions operating from vision to touch and touch to vision. Spatiotemporally congruent visuotactile stimulation stabilised participants' tactile and visual motion percepts. Nevertheless, participants were not able to track their motion percepts simultaneously in vision and touch, but could focus only on the percept in one sensory modality. Moreover, even under spatiotemporally congruent visuotactile stimulation the dynamics of tactile and visual percepts were governed by different temporal parameters. These results suggest that spatiotemporal visuotactile interactions facilitate convergence of visual and tactile perceptual dynamics, yet they do not necessarily enable the emergence of a unified multisensory consciousness.

TALKS

Talks Session 1: **MOTION AND SYMMETRY**

Sunday 14th June – Pacinotti Meeting Room 11.30 a.m – 1.00 pm

T1.1 TACTILE FLOW

Harris Laurence{1}, Sakurai Kenzo{2}, Beaudot William{2}

{1} York University ~ Toronto ~ Canada, {2} Tohoku Gakuin University ~ Sendai ~ Japan

Vestibular-somatosensory interactions are pervasive in the brain but it remains unclear why. Here we explore a possible function in the processing of self-motion. The contributions of physical accelerations and visual flow in detecting translation are well known, but tactile flow can also be obtained by running your fingers along a stationary surface while walking. We assessed the perceived speed and timing of self-motion with and without tactile cues. Subjects sat on a chair that oscillated laterally at 0.33Hz and either kept their hands on their laps or rested them lightly on an earth-stationary horizontal surface. They viewed a vertical grating, which oscillated at the same frequency as the chair with either peak velocity fixed and variable phase or phase fixed and peak velocity varied. In separate experiments participants judged whether the grating was exactly180° out-of-phase with their movement (i.e., Earth stationary), or whether it was moving faster or slower than their physical movement. Control conditions provided the tactile flow cue alone. Subjects matched the phase of their movement in all conditions (vestibular only, tactile only or combined) with a visual phase of around -7° (equivalent to vision preceding the movement by about 50ms). Tactile-alone and tactile-vestibular speed judgments indicated that motion was perceived as 4-8% faster than the visual stimulus, whereas vestibular-only judgments were accurate. In both phase and speed judgments, the changes in performance associated with added tactile flow appeared to result from a dominance of tactile flow rather than optimal integration of the two sources of motion information.

T1.2 NEURONAL REPRESENTATION OF OPTIC FLOW AS A CUE TO SELF-MOTION

Uesaki Maiko, Ashida Hiroshi

Department of Psychology, Graduate School of Letters ~ Kyoto ~ Japan

Optic flow is one of the most important visual cues to the estimation of self-motion (Gibson 1950; Warren et al., 1988). Representaion and processing of visual cues to self-motion have been associated with visual areas MT+, V6; multisensory areas ventral intra-parietal area (VIP), cingulate sulcus visual area (CSv), precuneus motion area (PcM); and vestibular areas parieto-insular vestibular cortex (PIVC), area p2v (Cardin & Smith, 2010; 2011). This study assessed whether optic flow is encoded differently according to presence or absence of a visually-induced sensation of self-motion (vection), using functional magnetic resonance imaging (fMRI). In the experiment, optic-flow stimulus consisting of dots moving along spiral paths was presented in blocks. During the stimulus-presentation blocks, participants held down one of the two buttons to report whether they were experiencing vection or no vection. Areas including MT+, V6, VIP and PIVC exhibited greater BOLD responses to optic-flow stimulation during self-reported states of vection, which may indicate that activation in MT+, V6, VIP and PIVC reflects vection. The results also suggest that VIP plays a crucial role in integration of optic-flow information and vestibular information (or luck there of) that is necessary for perception of self-motion. Supported by JSPS KAKENHI (B26285165).

T1.3 A THEORETICAL APPROACH TO MOVEMENT-RELATED TACTILE SENSORY SUPPRESSION

Juravle Georgiana{1}, Spence Charles{2}

{1} University of Hamburg ~ Hamburg ~ Germany, {2} University of Oxford ~ Oxford ~ United Kingdom

Understanding the contribution of sensory information to movement execution, as well as the importance of movement to the modulation of the various information impinging on our sensory receptors is a key topic nowadays in neuroscience. In what regards tactile perception, simple movements (e.g., finger/arm flexions), but also the goal-directed reach-to-grasp movements usually utilized in a laboratory setting, as well as the more naturalistic movements such as throwing/catching a ball in juggling or basketball have been of interest to researchers. Here, we summarize the research that has been published to date investigating the modulations of tactile perception during movement, with a focus on the timing of the delivery of tactile stimulation (i.e., from the very early preparation, through execution, and post-movement phases). We bring together existing research results on various tactile tasks performed during movement based on speeded/non-speeded measures of performance and highlight the debate between attentional versus suppression accounts of the data. We put forward and evaluate a novel hypothetical model concerning what happens to tactile perception in a moving effector – For this, we delineate amongst the various explanatory theses from the literature, such as dual-tasking, attention, the forward model, but also, more recently, the relevance of action/perceptual input, as well as discussing the importance of decisional factors to the processing of sensory information during movement.

T1.4 VISUO-VESTIBULAR CROSSMODAL AFTEREFFECTS IN SELF-MOTION PERCEPTION

Cuturi Luig, MacNeilage Paul

LMU - University Hospital Munich - German Center for Vertigo and Balance Disorders ~ Munich ~ Germany

In this study, we report for the first time that adaptation to optic flow induces robust crossmodal self-motion aftereffects in the vestibular domain. We assessed the dependence of these aftereffects on adaptor duration and their relationship with pure visual motion aftereffects. A motion nulling procedure was employed to measure the inertial (i.e. vestibular) stimulus needed to cancel the aftereffect induced by a visual-only optic flow. Experiments were conducted using a motion platform, equipped with a stereo visual display. On each trial, subjects experienced a visual-only adaptor stimulus consisting of expanding or contracting optic flow, followed by a 2 seconds physical movement either forward or backward in darkness. Then they indicated the perceived direction of the physical movement. Magnitude of the movement was varied from trial to trial to find the movement perceived equal to zero motion. We found that exposure to optic flow stimulation lasting 15 seconds induces a significant shift of the zero-motion point (i.e. an aftereffect) whereas shorter adaptor durations were ineffective, suggesting that sustained perception of self-motion (i.e. vection) is required to elicit these aftereffects. Magnitudes of crossmodal and purely visual aftereffects were not correlated, suggesting separate underlying mechanisms. These crossmodal aftereffects likely result from adaptation of multimodal neural mechanisms specialized for self-motion processing. In general, transfer of adaptation across modalities provides behavioral evidence for neural systems that constantly function to calibrate sensory modalities with each other as well as with the environment.

T1.5 THE EFFECT OF GAP SIZE ON THE PERCEPTION OF REGULARITIES IN VISION AND IN TOUCH

Lawson Rebecca, Ajvani Henna, Cecchetto Stefano

University of Liverpool ~ Liverpool ~ United Kingdom

In vision, regularities arising from mirror-reflectional symmetry appear to provide a powerful cue for the presence of a single object whereas regularities due to translational symmetry may signal the presence of two objects (Koning & Wagemans, 2009). This hypothesis suggests that the distance between two contours should influence the detection of mirror-reflection since larger distances should reduce the likelihood that both contours belong to the same object. In contrast, distance should have less influence on detecting translation. Contours belonging to different objects would not be expected to be near to each other, although it may be harder to detect correspondences between contours that are far apart. We investigated these predictions for both vision and haptics. Participants first did a haptic regularity detection task in which they felt two vertically aligned, raised line contours which were 25mm, 50mm or 100mm apart. They felt one contour with each hand and detected mirror-reflection and translation in separate blocks. Several days later they repeated this task visually, using photographs of the contours on a computer monitor. Increasing gap size had only a modest cost on haptic regularity detection with similar results for mirror-reflection and translation. Gap size also influenced visual performance but here, importantly, increasing the contour gap disrupted the detection of mirror-reflection more than translation. These results suggest that different processes are involved in regularity perception in touch and vision. Only the results for vision support the claim that reflection provides a powerful one-object cue whilst translation is a two-object cue.

T1.6 REVEALING SYMMETRY DETECTION OVER TIME: COMPARING VISUAL PERCEPTION USING A TOUCH-GUIDED, MOVING APERTURE TO HAPTIC PERCEPTION

Cecchetto Stefano, Lawson Rebecca

University of Liverpool ~ Liverpool ~ United Kingdom

A major issue in perception is whether results from behavioural studies reflect intrinsic properties of the environment or the way in which observers extract that information. Since both haptics and vision can extract shape information efficiently they can be compared to investigate this issue. Here, we compared performance across the two modalities using the same stimuli and task. Participants detected either mirror-reflectional symmetry or translational symmetry in 2D novel shapes. If symmetry is an intrinsic attribute of the environment, and observer's responses reflect this, we would expect the same pattern of results across vision and haptics. Different patterns would, instead, suggest that variation in how information is acquired by each modality matters. For vision, we replicated an interaction which has previously been reported, showing an advantage for detecting mirror-reflection across two contours if both belong to the same object, but an advantage for detecting translation if both contours belong to two different objects (Koning & Wagemans, 2009). In contrast, for haptics we obtained a one-object advantage for detecting both mirror-reflection and translation. When the visual stimuli were viewed through a small, moveable aperture whose position was controlled using a touch screen, performance became more like that of haptics, with a one-object advantage for both mirror-reflection and translation. Together these findings suggest that responses in symmetry perception studies may primarily reflect how stimulus information is acquired rather than intrinsic properties of the world.

Talks Session 2: **CROSS-MODAL INTEGRATION (1)**

T2.1 THE TASTE SYSTEM MODULATES SMELL PERCEPTION VIA NEURAL INTERACTIONS AT THE LEVEL OF PRIMARY SENSORY CORTEX

Maier Joost, Katz Donald

Brandeis University ~ Waltham, MA ~ United States

Taste and smell are intimately connected, as evidenced by the multisensory nature of our sense of flavor. In particular, psychophysical studies on odor intensity perception in humans, as well as behavioral work on flavor preference and aversion learning in rodents have suggested that taste influences smell. By combining multi-site electrophysiology and optogenetics in behaving rats, we demonstrate that the taste system modulates the olfactory system via interactions at the level of primary sensory cortex. We first identified neurons in olfactory cortex (OC) of rats that respond to taste stimuli and showed that these responses are correlated with responses of neurons in primary taste cortex (TC), suggesting functional interactions between these regions. This suggestion was confirmed by demonstrating that optogenetic inhibition of TC (TCx) during taste processing eliminates taste-selective responses from OC. Moreover, we found that optogenetic inhibition of ""spontaneous"" TC activity (i.e., activity in the absence of taste stimuli) modulates unisensory odor responses in OC. Increases and decreases in firing rate were observed equally likely, effectively changing the neural ensemble activated by an odor. We then probed a possible effect of altered odor representation on odor perception using an olfactory learning task. Indeed, TCx made rats unable to express learnt odor preferences, suggesting that inhibition of spontaneous TC activity changes the way an odor is perceived. Thus, we demonstrate an unexpected consequence of intrinsic functional connectivity between the taste and smell systems. That is, ""unimodal"" odor perception is dependent on the taste system, even in the absence of taste stimuli.

T2.2 SHIFTING VISUAL SPATIAL ATTENTION THROUGH EMOTIONAL SOUNDS

Zimmer Ulrike, Oertel Gina, Koschutnig Karl, Ischebeck Anja

Dep. of Psychology; University of Graz ~ Graz ~ Austria

Recently, we showed that a disgust sound shifts visual spatial attention away from its location (Zimmer et al., currently under revision). Our data are in contrast to angry sounds which increase spatial attention directly at their location (Brosch et al., 2009, JoCN). These results suggest that spatial avoidance might be specific for disgust. However, both studies had only used one single emotion. Therefore, we asked if spatial disgust avoidance could be replicated when comparing spatial cuing of disgust sounds directly with other emotionally negative sounds. Using fMRI, a left- or right sided sound cue (disgust, fear or neutral) preceded a visual target (a little white triangle) on the same (valid) or opposite (invalid) side. Participants were required to ignore the left/right sounds and detect the point of the triangle (up/down) as fast and accurately as possible. Behavioral results showed an interaction of emotion by validity. Specifically, there were more hits for targets that were invalidly cued with disgust compared to validly cued targets. The opposite pattern was obtained for fearful or neutral sound cues. During sound presentation, neuronal activity was increased in the insula cortex for disgust, but in the amygdala for fear. During target presentation, activity in visual cortex increased for targets invalidly cued with disgust and for targets validly cued with fear. The results confirmed that disgusting sounds are avoided by directing spatial attention away to the opposite side of space. Thus, spatial avoidance seems to be a key feature for disgust, but not for other negative emotions.

T2.3 LETTER AND NOVEL SYMBOL MULTISENSORY ENHANCEMENT DISSOCIATE IN BROCA'S APHASIA

Barutchu Ayla, Humphreys Glyn

Department of Experimental Psychology, University of Oxford ~ Oxford ~ United Kingdom

Vast complex cortical and subcortical neural networks, including temporal, frontal, and parietal associations regions, subserve multisensory processes, and converging evidence suggests that the activation of multisensory networks is not only task and attention, but also stimulus type dependent. We report data on multisensory processing in two patients with Broca's aphasia following stroke. MRI scans show that both patients have large lesions extending through the left temporal, parietal and frontal cortices, including the superior temporal gyrus. Multisensory processes were assessed using a letter (i.e., graphemes' and phonemes' of stop consonants) and a matched complex symbol-sound discrimination task. Stimuli were presented temporally synchronously and with stimulus onset asynchronies (SOAs) up to 300 ms. Healthy adult controls showed a classic profile with optimal multisensory enhancements for letter and novel stimuli with SOAs in close temporal proximity within 100 ms. In contrast, the patients showed a deficit in multisensory processing when discriminating letters; patients' responses were delayed when auditory phonemes were presented first, and phonemes did not enhance responses when the graphemes were presented first. Interestingly, both patients showed typical enhanced responses to audio-visual novel sounds and symbols when presented in close temporal proximity. These results suggest a possible dissociation of multisensory processes for letters, and perhaps more general language related stimuli, from novel audiovisual object processing. Importantly, some multisensory processing and enhancements remain intact in patients with Broca's aphasia but letter-based enhancement can be selectively disrupted.

T2.4 AUDIOVISUAL WORKING MEMORY AND MULTISENSORY PROCESSING IN THE MEDIAL PREFRONTAL CORTEX.

Plakke Bethany, Romanski Lizabeth

University of Rochester ~ Rochester ~ United States

Previous studies have implicated the medial prefrontal cortex (mPFC) in many processes including conflict, decision-making, audio-vocal control and motor processing. It also receives input from sensory cortex including the auditory and multisensory temporal lobe regions, although few studies have examined its response to naturalistic auditory or audiovisual stimuli. Our previous work has shown that ventrolateral prefrontal cortex (VLPFC) integrates face and vocal information and is necessary for audiovisual working memory. Here, we asked whether mPFC might also play a role in audiovisual processing. We recorded from mPFC in macaques while they performed an audiovisual nonmatch-to-sample task. During the task, subjects attended an audiovisual movie clip of face-vocalization as the Sample and detected the occurrence of a Nonmatch (when the face or vocalization differed from the Sample movie). Preliminary data showed mPFC cells are active during several task epochs including the sample (55%), the delay (79%), the match (41%) and the nonmatch (50%) period. Additionally, in a subset of units tested for multisensory processing, 44%= nonlinear multisensory, 8%= bimodal, 35% = unimodal visual and 13% = unimodal auditory. This differs from VLPFC where over half of tested units were multisensory and only 13% were unimodal visual (Diehl & Romanski, 2014). Interestingly, 61% of nonmatch cells were multisensory, which suggests that correct detection of the nonmatch requires the comparison of auditory and visual information. These results suggest a neuronal circuit for audiovisual working memory in the primate brain that includes both VLPFC and mPFC.

T2.5 THE DEVELOPMENTAL TRAJECTORY OF AUDIO-VISUAL INTEGRATION

Adams Wendy

University of Southampton ~ Southampton ~ United Kingdom

For various tasks, e.g. size estimation, adults optimally integrate information across modalities. In this process, (i) sensory weights reflect relative reliability: the combined estimate is closer to the more reliable estimates and (ii) reliability is increased, relative to uni-modal estimates. Previous studies suggest that optimal sensory integration emerges late - at around 10 years of age. Younger children rely on a single modality or combine information using inappropriate sensory weights. Children aged 4-11 and adults completed a simple audio-visual task, reporting the number of either beeps or flashes in uni-modal and bi-modal conditions. In bi-modal trials, beeps and flashes differed in number by 0, 1 or 2. All observers showed mutual interactions between the sensory signals: the reported number of flashes was influenced by the number of simultaneously presented beeps and vice versa. Furthermore, observes of ages weighted visual and auditory information appropriately, i.e. according to relative reliability. The degree of interaction decreased with age. For the youngest observers it was complete: they could not ignore the task irrelevant modality and reported equal numbers of flashes and beeps for bi-modal stimuli. Older observers showed much smaller effects of the task-irrelevant modality. Do these interactions reflect optimal integration? Integration, or partial integration predicts improved reliability in bi-modal conditions. In contrast, modality switching reduces reliability. Model comparison suggests that older observers employed partial integration, whereas younger observers (up to around 8 years) did not integrate, but followed a sub-optimal switching strategy, responding according to either visual or auditory information on each trial.

T2.6 MULTISENSORY PERCEPTION, BUT NOT MULTISENSORY STIMULI DRIVE THE ACTIVITY OF POSTERIOR SUPERIOR TEMPORAL SULCUS (PSTS)

Banerjee Arpan

National Brain Research Centre ~ Gurgaon ~ India

Speech perception emerges from harmonious interaction of multiple neural systems. “McGurk illusion” (McGurk and MacDonald, 1976), a classic example of how visual feedback shapes speech perception, provides an entry point to study the underlying brain networks. Earlier research has shown that modulating the degree of audio-visual (AV) integration by psychophysical parameters weakened the effect (Munhall et al., 1996, Pare et al., 2003, Alsius et al., 2007, Munhall et al., 2009, Nath and Beauchamp, 2012). Here, we performed an fMRI study on human volunteers when McGurk-stimuli (incongruent audio-video signal) were presented with varying AV lags. We observed across a large group of 16 volunteers there was a regime where the illusory perception was maximum, [-150, 300] ms in concordance with earlier studies. When the block at which maximum illusory response occurred was pooled for a group statistical parametric mapping (SPM) analysis with respect to rest we observed significant activations in inferior frontal gyrus (IFG), posterior superior temporal sulcus (pSTS), V5 and superior temporal gyrus (STG). In a conjunction analysis with blocks where minimum illusory perception was reported by volunteers, the highest difference was found in pSTS. In a regime where auditory preceded the visual stimulus, pSTS was not even activated. Functional connectivity among network nodes involving IFG, pSTS, auditory cortex/ STG and V5 using partial correlations were not altered by illusory perception but changed from a negative to positive AV lag. Overall, our results indicate neural activity in pSTS is most likely reflective of multisensory perception, but not multisensory stimulus processing.

Talks Session 3: **PERCEPTION IN THE BLIND**

Sunday 14th June – Pacinotti Meeting Room 3.00 – 5.00 pm

T3.1 SPACE AND TIME IN THE SIGHTED AND BLIND

Bottini Roberto{1}, Crepaldi Davide{2}, Casasanto Daniel{3}, Crollen Virginie{4}, Collignon Olivier{4}

{1} CIMeC- University of Trento ~ Trento ~ Italy, {2} University of Milan-Bicocca ~ Milano ~ Italy, {3} University of Chicago ~ Chicago IL ~ United States, {4} Université Catholique de Louvain ~ Louvain ~ Belgium

Across many cultures people conceptualize time as extending along a horizontal Mental Time Line (MTL). This spatial mapping of time has been shown to depend on experience with written text, and may also depend on other graphic conventions such as graphs and calendars. All of this information is typically acquired visually, suggesting that visual experience may play an important role in the development of the MTL. Do blind people develop a MTL? If so, how does it compare with the MTL in sighted? In this study we tested early blind, late blind and sighted participants in a space-time congruity task. We found that the MTL develops in the absence of vision, and that it is based on the same external frame of reference in sighted and blind people. Reading braille may provide the same experiential link between space and time in the manual modality as reading printed text provides in the visual modality. These results showing a similar MTL in sighted and blind participants contrast with previous results showing that the Mental Number Line (MNL) depends on different spatial coordinates in sighted and blind: Numbers are spatially represented in anatomical spatial coordinates in congenitally blind individuals (i.e. low-numbers/left-hand; high-numbers/right-hand), and external spatial coordinates in sighted and late blind individuals (i.e. low-numbers/left side of space; high-numbers/right side of space). The preferential use of different spatial coordinates to represent the MNL and the MTL in congenitally blind suggests that spatial representations of time and number may have different experiential bases.

T3.2 ACCESS TO VISUAL DISTANCE VIA A TIME-DELAYED TACTILE FEEDBACK DEVICE

Hartcher-O'Brien Jess, Auvray Malika, Hayward Vincent

Sorbonne Universites, UPMC Univ Paris, 06, UMR 7222, ISIR, F-75005 ~ Paris ~ France

In previous vision-to-touch sensory substitution approaches, including those used in most 'electronic white canes', typical techniques include mapping space-to-space, space-to-intensity, or space-to-frequency. To our knowledge, however, mapping space to time-delay has not previously been considered. Because organisms must predict impending collisions with obstacles or anticipate the moment of contact from approaching objects, these organisms have developed computational short-cuts where distance-to-target is assumed to be proportional to a time-interval. This short-cut often manifests itself in low-level sensorimotor behaviours and perceptual mechanisms. We studied whether untrained humans would spontaneously employ such a short-cut to estimate distance-to-obstacle in the absence of vision. The observers pressed a push button to search for a target object and a tactile pulse was delivered to the hand with a delay proportional to the distance to an obstacle detected by an optical range finder that they wore. The proportionality factor corresponded to a velocity of one m/s. The observers were not informed of the nature of the coding but after an initial exposure to the maximum and minimum distance in a distance-to-delay space of 1-4 meter (that is 1-4 second), they were able to spontaneously estimate the distance of the target. Upon randomised presentation of obstacle distances, the observers quickly calibrated their judgement of distance to target and were able to improve their estimates to within 0.1 m of the object. These results reveal that the amodal mapping of space to time-delay could be optimal for assisting collision-free ambulation and navigation in the absence of vision.

T3.3 FLEXIBLE USE OF SPATIAL REFERENCE FRAMES FOR TOUCH IN SIGHTED AND CONGENITALLY BLIND INDIVIDUALS

Schubert Jonathan, Badde Stephanie, Röder Brigitte, Heed Tobias

Biological Psychology and Neuropsychology, University of Hamburg ~ Hamburg ~ Germany

To localize touch, sighted individuals encode the anatomical, skin-based location, but automatically derive tactile stimulus location in an external reference frame by taking into account posture. In contrast, congenitally blind humans do not by default use an external reference frame in touch. We tested, whether these processing strategies are modifiable by task requirements. Sighted and blind participants performed a tactile localization task under varying task instructions. They localized a vibro-tactile target stimulus, presented randomly on the palm or back of one hand, while ignoring a tactile distractor on the other hand. Spatially incongruent distractors are known to impair localization performance in this task. The palms faced either both downward, or one downward and the other upward. Responses to target stimuli were instructed anatomically (palm or back of the hand), and, in a second session, externally (upper or lower location). Under anatomical instructions, both groups performed faster and more correctly when tactile distractors were located at congruent compared to incongruent anatomical locations relative to the target. Critically, under external instructions, performance in both groups was determined by whether distractors were in a congruent or incongruent external location, i.e., congruency was

predominantly coded externally. These effects were qualitatively comparable between groups, even if smaller in the blind group. The susceptibility of both sighted and blind individuals to task instructions suggests that the choice of reference frames in tactile processing is flexible and strategic, even in congenitally blind individuals who rely on anatomical spatial coding without specific instructions.

T3.4 AUDIO-MOTOR TRAINING AND SPATIAL COGNITION IN VISUALLY IMPAIRED CHILDREN AND ADULTS.

Gori Monica, Cappagli Giulia, Baud-Bovy Gabriel, Porquis Lope Ben, Finocchietti Sara

Istituto Italiano di Tecnologia ~ Genoa ~ Italy

Blind persons are impaired in understanding the relation between sounds presented in space (Gori et al., 2014) and tactile information about object orientation (Gori et al., 2010). In fact early-onset of blindness adversely affects psychomotor, social and emotional development (Gilbert and Awan, 2003). Most of the technology available (e.g. Kajimoto et al., 2003) to date is not suitable for young children with sensory impairments such as visual disability. On the basis of our research, we developed a new set of rehabilitative devices for young visually impaired children. In the talk we will present our scientific studies on how an audio-motor training can be used to improve spatial cognition in visually impaired children and adults. We will also present the ABBI device (Audio Bracelet for Blind Interaction): a new rehabilitative solution to improve spatial, mobility and social skills in visually impaired individuals.

T3.5 ALTERED MULTISENSORY PROCESSING AFTER A TRANSIENT PERIOD OF A TOTAL BLINDNESS FROM BIRTH

Röder Brigitte, Putzar Lisa, Guerreiro Maria

University of Hamburg ~ Hamburg ~ Germany

Recent work has suggested that multisensory development is characterized by both regressive events and growth processes resulting in a refinement of multisensory functions. The role of experience for multisensory development can be addressed in individuals who were born with dense bilateral cataracts whose vision was restored later in life. In a recent functional magnetic resonance imaging study, we investigated the neural processing of auditory, visual and audio-visual speech stimuli. While we found crossmodal interactions in auditory areas in matched sighted controls, this effect was absent in the cataract-reversal individuals. Crucially, in the latter we observed lower activity to audio-visual stimuli than to visual stimuli in visual cortex, suggesting a suppression of visual processing by concurrent auditory stimulation. We speculate that the suppression of visual processing by either auditory or tactile stimuli might be due to a reorganization of visual areas during the period of blindness, causing a not fully reversible change in the weighting of auditory and visual inputs during crossmodal stimulation in visual areas. During the period of blindness, noisy visual inputs from the deprived retina were possibly suppressed to reduce interference during non-visual stimulation.

T3.6 INDEPENDENT DEVELOPMENTAL TRAJECTORIES FOR BIOLOGICAL MOTION AND FACE PROCESSING

Bottari Davide{1}, Troje Nikolaus Friedrich{2}, Ley Pia{1}, Hense Marlene{1}, Kekunnaya Ramesh{1}, Röder Brigitte{3}

{1} University of Hamburg ~ Hamburg ~ Germany, {2} Department of Psychology, Queen's University ~ Kingstone ~ Canada, {3} LV Prasad eye Institute ~ Hyderabad ~ India

Few models in humans allow the investigation of sensitive periods of functional development. The evaluation of the functional recovery in individuals who had suffered from congenital dense bilateral cataracts (opaque lenses that prevent patterned light to reach the retina) after the cataracts had been surgically removed provides such rare opportunity. Here we investigated 12 individuals with a history of congenital cataracts in a Biological Motion processing task while the EEG was recorded. Task of the participants was to detect a moving point light display of a cat amongst moving point-light displays of human walkers (biological motion, BM) and scrambled versions of the latter. The N1 was modulated by BM both in the cataract-individuals and in controls. Indeed, both groups were indistinguishable with respect not only to the N1 amplitude modulation but with respect of the scalp topography and the latency of this effect. In line with the neural results, the congenital cataract individuals performed indistinguishable from their controls in the EEG task and in an independent behavioural task assessing the thresholds for detecting biological motion. Since congenital cataract reversal individuals did not show modulation of the N170 for faces vs. other objects, these data suggests independent developmental trajectories for these visual functions.

T3.7 A NUMBER-FORM AREA IN THE BLIND

Abboud Sami{1}, Maidenbaum Shachar{1}, Dehaene Stanislas{2}, Amedi Amir{3}

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Medical Research Israel-Canada, Faculty of Medicine, The Edmond and Lily Safra Center for Brain Sciences (ELSC), The Cognitive Science Program, The Hebrew University of Jerusalem ~ Jerusalem ~ Israel

Distinct preference for visual number symbols was recently discovered in the human right inferior temporal gyrus (rITG). It remains unclear how this preference emerges, what is the contribution of shape biases to its formation and whether visual processing underlies it. Here we use congenital blindness as a model for brain development without visual experience. During fMRI, we present blind subjects with shapes encoded using a novel visual-to-music sensory-substitution device (The EyeMusic). Greater activation is observed in the rITG when subjects process symbols as numbers compared with control tasks on the same symbols. Using resting-state fMRI in the blind and sighted, we further show that the areas with preference for numerals and letters exhibit distinct patterns of functional connectivity with quantity and language-processing areas, respectively. Our findings suggest that specificity in the ventral 'visual' stream can emerge independently of sensory modality and visual experience, under the influence of distinct connectivity patterns.

T3.8 CORE KNOWLEDGE OF GEOMETRY IN CONGENITALLY BLIND ADULTS

Heimler Benedetta{1,2}, Behor Tomer{1,2}, Deheane Stanislas{1,3}, Amedi Amir, {3}

{1} Department of Medical Neurobiology, Institute for Medical Research Israel-Canada, Faculty of Medicine, Hebrew University of Jerusalem, Hadassah Ein-Kerem; {2} The Edmond and Lily Safra Center for Brain Research, the Hebrew University of Jerusalem, Hadassah, {3} Cognitive Neuroimaging Unit, Institut National de la Sante´ et de la Recherche Me´dicale; Neurospin Center, Commissariat a` l'e´nergie atomique (CEA), Division Sciences de la Vie (DSV), Institut d'imagerie Biome´dicale (I2BM); University Paris 11; Colle

In the last decade the presence of core geometry intuitions has been demonstrated in young children as well as in adults completely lacking geometrical language or geometrical education. However, it remained still unknown whether and to what extent, such intuitions can arise without any access to visual experience throughout the lifespan. To unravel this issue, we took advantage of a visual deviant detection task consistently used in previous works to test sensitivity to geometric invariants, and tested a group of congenitally blind adults in a tactile version of it. We found that congenitally blind participants spontaneously used geometric concepts such as curves, parallelism, right angles, quadrilaterals and relative distances among elements, to detect intruders in the tactile displays. Interestingly, geometric concepts requiring complex spatial transformations and mental rotation abilities such as symmetry, homothecy and chirality were the least detectable among blind participants, similarly to what has been previously reported with young children and adults naive to geometry. These results provide evidence suggesting that core geometry intuitions do develop also in the absence of visual experience.

Talks Session 4: **SPACE PERCEPTION**

Sunday 14th June – Fermi Meeting Room 3.00 – 5.00 pm

T4.1 EYE MOVEMENTS MODULATE THE ACOUSTICS OF THE EXTERNAL EAR CANAL

Gruters Kurtis G{1}, Shera Christopher A{1}, Groh Jennifer{2}

{1} Duke University ~ Durham, North Carolina ~ United States, {2} Harvard Medical School ~ Cambridge, Massachusetts ~ United States

Eye movements can change the relationship between eye-centered visual space and head-centered auditory space, a relationship that must be "known" by the brain in order to coordinate a unified sense of audio-visual space. Eye position modulates auditory activity in the inferior colliculus (Porter et al., 2007; Bulkin and Groh, 2012), the intraparietal sulcus (Mullette-Gillman et al., 2009), and the superior colliculus (SC; Lee and Groh, 2012). Presumably, this modulation helps the auditory system calculate an eye-centered representation of auditory space identified in the motor signals of the SC (Lee and Groh, 2012). It is not clear when or where in auditory system eye movements first influence auditory processes. The earliest possible point involves the descending system that controls the auditory transduction apparatus (otoacoustic emissions and related musculature). This system can be evaluated by microphone measurements in the external ear canal. We made such measurements in monkeys (n=3) and humans (n=35) as they made saccades from a central fixation point to various locations along the horizontal azimuth. We found statistically significant effects of eye movements in both humans and monkeys (ANOVA, $p<0.05$). These results show that eye movements influence processes at the auditory periphery. Such changes are likely sufficient to pass eye position information throughout the entire auditory system and support a variety of interactions between vision and audition. These interactions may contribute to perceptual binding of visual and auditory cues such as for lip reading or ventriloquism, and may be useful in developing audiovisual hearing devices.

T4.2 YOUR HAND IS NOT A PERCEPTUAL RULER: CHANGES IN ACTION CAPACITY INFLUENCE AFFORDANCES BUT NOT SIZE ESTIMATES

Collier Elizabeth, Lawson Rebecca

University of Liverpool ~ Liverpool ~ United Kingdom

Linkenauger, Witt and Proffitt (2011) proposed that the perceived size of graspable objects is scaled by perceived grasping capacity. However, it has been shown that this scaling effect may only occur when observers include non-visual factors, such as affordances, in their judgements (Woods, Philbeck & Danoff, 2009). Affordances reflect the relationship between action capacity (e.g., grasping ability) of the observer and action potentials (e.g., whether an object can be grasped). Thus changes to action capacity should influence affordances but may not necessarily affect perceived object size. We tested the specific claim that right-handed observers overestimate both the size and the grasping capacity of their right hand relative to their left, leading them to underestimate the size of objects to-be-grasped in the right hand (Linkenauger et al, 2011). We found that effects of handedness only occurred when observers made judgements about affordances (whether they believed they could grasp an object; Experiment 1). The presence of the right compared to the left hand near to an object did not influence the perceived size of that object in a size matching task (Experiments 2 and 3). Also when action capacity was physically restricted by taping together the fingers, observers recalibrated their perception of affordances but object size estimates were unaffected (Experiment 4). Thus observers appropriately altered perceived affordances to reflect their action capacity but we found no evidence to support the claim that estimates of spatial extent are scaled by action capacity.

T4.3 ADAPTATION OF HAPTIC SURFACE ORIENTATION: NO TRANSFER BETWEEN DIFFERENT UNIMANUAL EXPLORATION MODES

van Dam Loes{1}, Plaisier Myrthe{2}, Glowania Catharina{1}, Ernst Marc{1}

{1} Bielefeld University ~ Bielefeld ~ Germany, {2} Vrij Universiteit Amsterdam ~ Amsterdam ~ Netherlands

When exploring the shape of an object using touch (haptic exploration) we can use different strategies. We can use multiple fingers to sample several locations on the object in parallel, i.e. at the same time. Alternatively, we can sample the object in a serial fashion by moving one finger along its surface. Do these different exploration strategies form a common haptic percept or is the perceptual representation dependent on the mode of extraction? We addressed this question by investigating transfer of surface orientation adaptation between exploration modes. In separate sessions, participants explored a 10 deg rotated surface either by moving one finger along the surface (Serial Exploration) or by keeping static contact with two fingers (Parallel Exploration) for a 30sec adaptation period (4sec top-up between trials). Before and after adaptation participants judged whether the left or right side felt higher for a range of surface orientations. Adaptation aftereffects were identified by measuring changes in the orientation at which the surface was perceived as level. If exploration modes share a common representation, adaptation using one exploration mode should fully transfer to the other exploration mode. However, if the exploration modes yield independent representations, no transfer should occur. Our results showed aftereffects for both the Serial and Parallel Exploration modes, when the same exploration mode was used for adaptation and testing. However, adaptation did not transfer between exploration modes, indicating that the perceptual system does not build a single common haptic representation. Instead perception strongly depends on how the information was obtained.

T4.4 VISUOTACTILE LOCALIZATION DURING ARM MOVEMENTS

Maij Femke, Medendorp Pieter

Radboud University ~ Nijmegen ~ Netherlands

People systematically misjudge the location of a briefly presented sensory stimulus while moving its receptor surface. For example, flashes are mislocalized when presented near the time of saccades (moving retina) just as are brief tactile stimuli felt with the fingertip of a moving arm (moving skin). We have recently proposed that these unimodal localization errors originate from temporal uncertainty about the stimulus combined with the performed movement. Recent work suggests that these errors may stem from a supramodal representation by showing that auditory stimuli are also mislocalized when moving the eyes, even when the head (ears) remains stationary. Why do these supramodal localization errors occur? Here we instructed participants to localize a visual, tactile or visuotactile stimulus presented near or/and on their index finger while making a fast arm movement. Their gaze was fixed at either the start or end point of the movement. Our preliminary results show larger localization errors for the unimodal (tactile) condition compared to the supramodal (visual) condition. More experiments and analyses are currently under way to test how spatial representations in different reference frames interact in these conditions.

T4.5 COMPRESSION OF TIME AND SPACE BETWEEN THE VISUAL AND THE TACTILE SENSES

Zimmermann Eckart, Derichs Christina, Fink Gereon

Cognitive Neuroscience, Institute of Neuroscience and Medicine (INM-3), Research, Centre Jülich ~ Jülich ~ Germany

Multisensory integration provides continuous and stable perception from the separate inputs of the different senses. Here, we present evidence that time and space between the visual and the tactile senses actively converge to enable perceptual unity. We used the paradigm of compression that induces shifts in time and space when probe stimuli are degraded, e.g., by a visual mask (Zimmermann et al., 2014). Subjects had to estimate the duration of temporal intervals defined by a tactile and a visual masked stimulus. We observed a strong (~100 ms) underestimation of the interval when the stimuli from both senses appeared to occur from the same position in space. In contrast, when the visual and tactile stimuli were discrete in space, interval perception was almost veridical. Temporal compression depended on matching features of the probe stimuli and was absent when the orientation of the tactile and visual probes was incongruent. We also observed compression in the spatial domain where tactile stimuli shifted the apparent position of visual probes. Our results suggest that an active mechanism combines visual and tactile stimulus information in time and space if the stimuli seem to belong to the same external object.

T4.6 SPATIAL REFERENCE FRAME OF HAPTIC CONTEXT LEARNING: EGOCENTRIC OR ALLOCENTRIC?

Assumpcao Leonardo, Shi Zhuanghua, Zang Xuelian, Müller Hermann Joseph, Geyer Thomas

Ludwig Maximilian's-University Munich ~ Munich ~ Germany

Visual search refers to looking for a given object in a busy environment. Items differing physically from others, or that are expected by observers attract attention. Furthermore searched scenarios are not 'a-historic', oftentimes target re-occurs within identical distractor context facilitating search, i.e., contextual-cueing effect[1]. Likewise, a novel haptic-search study revealed evidence for contextual-cueing in the haptic modality[2]. Here, by manipulating hand position (palm-up/down) we investigated whether memory for target-distractor associations in haptic search is supported by ego/allocentric representations. Participants performed a haptic search task, divided in training and test phases. Unbeknown to them, half of the trials repeated target-distractor arrangements. In the learning phase participants detected the target faster in repeated configurations, indicating a haptic contextual learning. In the test phase, providing the relationship between configuration and fingers remained stable across phases (egocentric), learned contextual cues persisted, whereas when the relationship between configuration and fingers changed, but their environmental (X-/Y-) coordinates were maintained (allocentric), the contextual effect disappeared. We take this double-dissociation to mean that haptic contextual learning is coded egocentrically, similar to its visual counter-part. We discuss our findings under the notion of modality in/dependent memory representations in search paradigms.

T4.7 THE SLOW DEVELOPMENT OF AN ADULT-LIKE EXTERNAL SPATIAL FRAME OF REFERENCE FOR TOUCH

Nava Elena, Bolognini Nadia, Turati Chiara

University of Milan-Bicocca ~ Milan ~ Italy

The illusion of touching one's own hand (SRH, the Somatic Rubber Hand) is induced by moving the index finger of a blindfolded participant on a rubber hand while the experimenter synchronously strokes the hand of the participant. The SRH has been typically used to investigate the presumably crucial role of vision in driving sense of ownership and recalibration of position sense towards the rubber hand. This illusion arises from the conflict between tactile and proprioceptive information that the brain resolves by mapping two spatially separated tactile stimuli onto the same location in peripersonal space, thus perceiving them as self-touch. Here, we tested whether 4-5 and 8-9 years old children, as well as a group of naïve adult controls are sensitive to the SRH. We found that both groups of children and adults experienced spatial recalibration of their own hand towards the rubber hand. However, the amount of recalibration towards the rubber hand was larger in adults than in children, suggesting that the misalignment of proprioceptive and tactile reference frames causes less conflict in children than adults. This may reflect less tactile-proprioceptive integration abilities in children but, in turn, fast re-weighting of tactile and proprioceptive cues in the absence of vision. This evidence is also suggestive of a less automatic remapping of tactile stimuli into an external frame of reference in children, or a more flexible use of external and internal frame of references when localizing limb positions through tactile and proprioceptive interactions.

T4.8 APPROACHING THREAT MODULATES VISUOTACTILE CODING IN PERIPERSONAL SPACE

De Haan Alyanne, Smit Miranda, Van der Stigchel Stefan, Dijkerman Chris

Utrecht University, Experimental Psychology, Helmholtz Institute ~ Utrecht ~ Netherlands

The region surrounding our body (i.e. peripersonal space) is coded in a multimodal representation by fronto-parietal bimodal neurons integrating tactile stimuli on the body with nearby visual stimuli. This has often been suggested to serve a defensive purpose, which we propose could be mediated through visuotactile predictions. An approaching threat would then be of particular interest to peripersonal

space processing. To investigate this prediction we asked participants to respond as fast as possible to a tactile stimulus on the hand, while looking at an animation of an approaching or receding spider or butterfly. Tactile stimulation was applied at one of 25 possible time points during the animation. Tactile reaction times were faster when an approaching stimulus was closer to the hand at the time of tactile presentation. Critically, this effect of distance on reaction times was larger when participants saw an approaching spider compared to an approaching butterfly, but only for participants that were afraid of spiders. This finding demonstrates that the perceived threat of an approaching stimulus modulates visuotactile coding in peripersonal space and is consistent with the idea that visuotactile predictions are an important aspect of peripersonal space processing.

Talks Session 5: **BODY OWNERSHIP AND AWARENESS**

Monday 15th June – Pacinotti Meeting Room 11.30 – 1.00 pm

T5.1 BODY OWNERSHIP TOWARDS THE MOVEMENT END-EFFECTOR MODULATES MOTOR PERFORMANCE UNDER VIOLATION OF MOTOR INTENTION

Kilteni Konstantina{1}, Burin Dalila{2}, Rabuffetti Marco{3}, Pia Lorenzo{2}, Slater Mel{2}

{1} EventLab, University of Barcelona, Department of Personality, Evaluation and Psychological Treatment ~ Barcelona ~ Spain, {2} SAMBA- SpAtial Motor and Bodily Awareness research group- Department of Psychology, University of Turin ~ Turin ~ Italy, {3} Biomedical Technology Department, IRCCS Don Carlo Gnocchi Foundation ~ Milan ~ Italy

When we perform voluntary actions, our sense of body ownership and agency are dynamically shaped through an interaction between efferent and afferent signals under a consistent accordance between our intention-motor program and the perceived sensory reafferences. Previous studies examined the effects of spatiotemporal mismatches between the actual and intended consequences of the movement on motor performance and perception. We investigated the specific role of body ownership on motor performance when the seen and the intended movements do not match. Thirty healthy participants were asked to draw straight vertical lines while seeing a virtual body either from a first or a third person visual perspective. Initially, the virtual arm moved congruently with the participant's arm, drawing straight lines synchronously. At a certain point, the movements of the virtual hand deviated spatially from the real hand movements, drawing clockwise ellipses instead of lines. We found that the ovalization index (i.e. the deviation of the real trajectory from an absolute vertical line) was significantly higher in 1PP (i.e., when the seen hand was attributed to the own body) as compared to 3PP (i.e., when the hand was attributed to another person). Additionally, this was positively correlated to the degree of body ownership and its pattern revealed an adaptation of the real drawings to the seen ellipses - as if copying them. We interpret the present findings in terms of a different weighting of prediction errors in updating one's sensorimotor system depending on the experienced body ownership.

T5.2 FLEXIBLE EXPANSION OF THE TEMPORAL WINDOW OF VISUOTACTILE INTEGRATION DURING BODY OWNERSHIP ILLUSIONS.

Maselli Antonella{1}, Kilteni Konstantina{2}, Lopez-Moliner Joan{3}, Slater Mel{1}

{1} Barcelona University, EVENT Lab ~ Barcelona ~ Spain, {2} Karolinska Institute ~ Stockholm ~ Sweden, {3} Barcelona University, Visca Lab ~ Barcelona ~ Spain

Body ownership illusions (BOIs) are rooted in the binding of multisensory stimuli streaming from the physical body and from a fake body seen in first person perspective. Once established, BOIs have been shown to affect the processing of sensory cues as well as higher-order aspects of behavior. In this study we specifically tested the hypothesis that BOIs extend the temporal window for the integration of spatially congruent visuotactile cues. The rationale is that BOIs establish an illusory causal binding between tactile and visual stimuli on the body surface, and that such causal binding acts as a top-down factor enhancing the probability of integrating temporally misaligned cues. We implemented a temporal order judgment (TOJ) task in an immersive virtual reality setup in which vivid BOIs could be elicited. In two independent experiments we tested (i) the role of causal binding (manipulating the semantic congruency among the visual and tactile target cues of the TOJ) and (ii) the role of BOIs in establishing such causal binding (manipulating directly the sense of ownership). Results from both experiments support our hypothesis, showing that the temporal window for visuotactile integration (measured as the just noticeable difference –JND- extracted from the TOJ) is significantly increased when the visual and tactile target cues appear to be semantically congruent (experiment 1), through a casual binding mediated by the BOI (experiment 2). Importantly, subjective reports of illusory feelings are positively correlated with individual JNDs. These results provide new evidence for the impact of BOIs on multisensory integration.

T5.3 WHERE AM I? INVESTIGATING WHICH PERSPECTIVES ARE TAKEN ON AMBIGUOUS TACTILE SYMBOLS

Auvray Malika{1}, Arnold Gabriel{2}, Hartcher O'Brien Jess{1}, Hayward Vincent{1}, Spence Charles{1}

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The studies reported here investigated the reference frame that people take with respect to tactile stimuli received on their body surface. Ambiguous tactile symbols (the letters b, d, p, q or circles that can be interpreted as moving clockwise or anticlockwise) were drawn on people's various body parts. People can interpret the stimuli either according to a centred or a decentred perspective (i.e., centred on a spatial location different from that of the observer), as if they perceived their own body from the outside. The results revealed that the adopted reference frames vary with the stimulated surface and with its orientation. When the stimuli are presented on the stomach, eighty percent of people adopt a centred perspective, either head- or trunk-centred. When they are presented on the fingertips, stimuli are predominantly interpreted according to a centred perspective when the hand is facing outward and a decentred one when the hand is facing inward. There is far more variability when stimuli are presented on the palms. Our studies also reveal that participants have a natural reference frame, that does not reduce to a mere cognitive choice and that the cost of changing reference frames is higher for centred than for decentred observers. Finally, when the participants are trained to adopt a novel reference frame on one body surface, there is a transfer of learning to other body surfaces. This research has implications for understanding three-dimensional object perception through tactile interfaces and for understanding the factors that influence perspective taking.

T5.4 MODELING THE MECHANISMS OF BODY REPRESENTATIONS USING MACHINES: EXPLORING THE "SELF-TOUCH" SCENARIO IN THE ICUB HUMANOID ROBOT WITH ARTIFICIAL SKIN

Hoffmann Matej, Roncone Alessandro, Metta Giorgio

iCub Facility, Istituto Italiano di Tecnologia ~ Genova ~ Italy

Humans and animals seamlessly command their complex bodies in space and concurrently integrate multimodal sensory information. To support these capabilities, it seems that some representation of the body is necessary. In this regard, a number of concepts like body schema and body image were proposed. However, while the field is rich in experimental observations, it is largely lacking mechanisms that explain them. Computational models are scarce and address at the most isolated subsystems. Humanoid robots possess morphologies – physical characteristics as well as sensory and motor apparatus – that are in some respects akin to human bodies and can thus be used to expand the domain of computational modeling by anchoring it to the physical environment and a physical body and allowing for instantiation of complete sensorimotor loops. We present our modeling endeavor in the iCub - a baby humanoid robot with 53 degrees of freedom, two cameras with an anthropomorphic design, joint encoders in every joint, and a whole-body artificial skin. The developmental trajectory we follow is one hypothesized by Rochat (1998), namely learning about the body through self-stimulation or self-touch. This behavior was instantiated in the robot and the data thus collected is fed into biologically motivated learning algorithms (such as self-organizing maps) in order to first obtain analogs of primary tactile and proprioceptive maps (areas 3b and 3a). Later, we explore the contingencies induced in tactile and proprioceptive afference by the self-touch configurations and study how they may give rise to first body models with spatial properties.

T5.5 THE TEMPORAL DYNAMICS OF MIRRORING OTHERS' TACTILE SENSATIONS: EFFECTS OF TYPE OF TOUCH, PERSONALITY AND SELF-RELATEDNESS

Gillmeister Helge{1}, Adler Julia{2}

{1} University of Essex ~ Colchester ~ United Kingdom, {2} University Medical Centre Mainz ~ Mainz ~ Germany

When we watch others, we automatically simulate their actions, emotions, and somatic sensations. Here we present a series of studies which show that the neural time course of simulating others' tactile sensations in one's own somatosensory system strongly depends on aspects of the visual stimuli and the observer himself. We use somatosensory event-related potentials (ERPs) as a direct physiological correlate of touch mirroring, and we demonstrate that the observation of others' touch can affect ERPs to the observer's own felt touches at all latencies, starting from 45 ms post-stimulus. The latency of mirror touch was strongly affected by the type of touch observed (passively received vs. actively sought), complementing research on passive / active touch mirroring in perception (Gillmeister, 2014). Self-relatedness of the viewed touch (own vs. other face; human vs. rubber hand) systematically modified touch mirroring at early latencies. For example, we found that early-latency mirror touch for viewing one's own face is absent in observers with altered self-perception, suggesting that a lack of automatic self-related resonance may be at the heart of psychological symptoms like depersonalisation. We also investigated the relationship between touch mirroring, self-relatedness, and direct or indirect measures of empathy, including perspective-taking, and direct and indirect measures of interoceptive awareness.

T5.6 MULTISENSORY INTERACTIONS DURING OBSTACLE AVOIDANCE

Menger Rudmer

Utrecht University ~ Utrecht ~ Netherlands

Multisensory coding of the space surrounding our body, the peripersonal space (PpS), is crucial for motor control. Recently, it has been proposed that an important function of PpS coding is that it allows anticipation of tactile consequences of contact with a nearby object. Indeed, a recent study showed that performing goal-directed grasping movement induces a continuous remapping of PpS as a function of on-line sensorimotor requirements. Here we were interested to study whether remapping of the PpS can be induced by objects that are not a direct target of the action, and not touched by the observer but that are nevertheless relevant when performing the action. We used a cross-modal obstacle avoidance paradigm, in which participants reached passed an obstacle to grasp a second object. Participants indicated the location of tactile targets delivered to the hand during the movement, while a visual distractor was sometimes presented on a to-be-avoided object. The tactile and visual stimulation was triggered when the reaching hand passed a position drawn randomly from a continuous set of predetermined locations. We observed differences in visuotactile interaction during obstacle avoidance dependent on the location of the trigger. Enhanced visual interference for tactile stimulation occurred when the hand was near the obstacle. The results show that obstacles, which are relevant for action but are not to-be-interacted with automatically evoke the tactile consequences of interaction. This suggests that PpS remapping extends to obstacle avoidanc and that PpS not only calculates the tactile results of actions but also of potential collisions.

Talks Session 6: **PRIMING AND PREDICTION**

Monday 15th June – Fermi Meeting Room 11.30 – 1.00 pm

T6.1 A TOUCH OF BITTER CHOCOLATE: REMOTE TACTILE PRIMING IN A BLIND TASTE TEST

Styles Suzy

Nanyang Technological University ~ Singapore ~ Singapore

Haptic experiences can influence the hedonic experience of food and drink (c.f., Spence, Hobkinson, Gallace and Piqueras Fiszman, 2013), but how do tactile sensations not involved in the act of eating influence our sense of a flavor? Blindfolded participants tasted samples of 50% and 90% cocoa chocolate. In a matching task, participants heard speech sounds /i/, /a/, /u/ and /y/ ('ü'), and selected which of the two chocolate flavours was the best match for each sound. Participants then rated each chocolate's bitterness by dropping a ball into one of seven bowls comprising a physical scale. Ratings were performed using two different balls (one smooth, one knobbly). After the blindfolded test, participants matched each speech sound to visual shapes in an 11x11 array of shapes varying in size, and edge convolution (asterisk to circle). 90% chocolate attracted more /i/ and /y/ responses (/i/: $p<.01$, /y/: $p<.05$), and higher bitterness ratings. 50% attracted more /a/ responses ($p<.001$), and lower bitterness ratings. /i/ also attracted smaller, more convoluted shapes, and /a/, larger shapes (/i/: $p<.01$; /u/: $p=.001$). This indicated common sensory mapping between bitterness, /i/, and highly convoluted shapes. Critically, bitterness ratings were modulated by tactile sensations – Chocolate was judged to be more bitter when rated using the knobbly ball ($F(1,75)=4.8$, $p<.05$). This indicates a bitter-sweet symphony of sensory mappings between flavor (bitterness), sound (/i/), sight (convoluted-shape), and touch (knobbly), in a single group of participants. We discuss the sensory underpinnings of speech processing and remote tactile priming in this multimodal context.

T6.2 TACKLING HISTORY EFFECTS IN MULTISENSORY DECISIONS

Otto Thomas, D'Souza Rebecca

School of Psychology and Neuroscience, University of St Andrews ~ St Andrews ~ United Kingdom

In multisensory research, many paradigms require subjects to make perceptual decisions about signals presented in random order. For example, in the classical redundant signals paradigm, subjects are asked to detect the onset of combined audio-visual signals that are randomly interleaved with either the auditory or the visual component signal. To study multisensory benefits (like the speed-up of reaction times), performance with combined signals is typically compared to performance with the individual component signals using some combination rule (e.g., probability summation; Raab, 1962). In many cases, these rules do not consider effects of trial history on performance, which can occur due to well-known modality or task switching costs in random sequences. In consequence, without considering history effects, a proper interpretation and modelling of the targeted multisensory benefit is difficult. To tackle the effect of trial history, we used the redundant signals paradigm with auditory (1.8-2.2 kHz band-pass noise) and visual target signals (coherently rotating dots). Critically, we interleaved the trial sequence with additional intermediate targets (a 440 Hz pure tone combined with a colour change of dots). When measured after intermediate targets, the redundant signals effect is reduced revealing a clear contribution of trial history on multisensory benefits. Based on a systematic analysis of response time distributions, we then demonstrate that history effects can be separated from the targeted multisensory benefit using an extended probability summation framework (Otto & Mamassian, 2012). Our study highlights that history effects should be considered for a better understanding of the cognitive architectures underlying multisensory benefits.

T6.3 NEURAL BASES OF PREDICTION OF IMPACT TO THE FACE OF LOOMING VISUAL STIMULI: A NON-HUMAN PRIMATE FMRI STUDY.

Clery Justine, Guipponi Olivier, Odouard Soline, Wardak Claire, Ben Hamed Suliann

Centre de Neuroscience Cognitive-UMR5229 ~ Bron ~ France

In a recent study (Cléry et al. 2015), we show that looming stimuli towards the face enhance tactile sensitivity at the predicted time and location of the impact, suggesting the involvement of multisensory integration areas in the prediction of impact to the body. In order to test this hypothesis and identify the neural bases of the prediction of impact to the face by a looming stimulus, we use functional magnetic resonance imaging (fMRI) in monkeys. Specifically, very weak airpuffs (modeling the impact to the body) were delivered either after a degraded looming visual stimulus, at the predicted time of impact (temporal predictive condition), or during the visual sequence (simultaneous visuo-tactile presentation). Temporally predictive airpuffs could also be delivered either at the predicted location of the impact on the face (spatially congruent condition), or at the opposite side (spatially incongruent condition). We show that maximal cortical activations are observed when the looming stimulus spatially and temporally predicts the tactile stimulus. The next best condition is the temporally predictive spatially incongruent condition. Hardly any activations are observed for the simultaneous visuo-tactile condition. These predictive processes activate, in addition to striate and extrastriate visual areas, a parieto-frontal network composed of the ventral intraparietal area VIP, prefrontal area 44 and premotor area F4. Thus, the prediction of the heteromodal consequences of a looming visual stimulus onto the tactile modality recruits a network previously described for its contribution to multisensory integration. These observations are discussed in the context of a peripersonal defense space cortical representation.

T6.4 PREDICTING THE MULTISENSORY CONSEQUENCES OF ONE'S OWN ACTION

van Kemenade Bianca, Arikan Ezgi, Straube Benjamin, Kircher Tilo

Philipps-Universität Marburg ~ Marburg ~ Germany

In order to achieve efficient sensory processing, we constantly predict the sensory consequences of our own actions to distinguish internally and externally generated stimuli. This is thought to occur through a forward model. So far, the model has been tested with unimodal stimuli only. In the current study, we investigated whether the forward model creates multisensory predictions. Participants were instructed to press a button after a cue, which would elicit the appearance of either a visual or auditory stimulus, or both. The stimuli were presented either directly with the button press, or after a variable delay. Participants were instructed to report whether they detected a delay between their button press and the stimulus in one of the two modalities. Analysis of unimodal and bimodal trials using psychometric functions showed that the 50%-threshold for bimodal trials was significantly lower than for unimodal trials. Further analyses of bimodal trials showed that when the non-attended modality was not delayed, the 50%-threshold was significantly lower than when this modality was delayed. To our knowledge, this study is the first to show multisensory facilitation of perceiving the consequences of one's own action. Furthermore, we show that timing matters: when the non-attended modality is not delayed, i.e. congruent with the action, performance is better than when the predictions of both modalities are violated. This supports the idea that the forward model includes predictions for all modalities and consequently contributes to multisensory integration in the context of action.

T6.5 CROSS-MODAL RECALIBRATION INTEGRATES LOCAL AND GLOBAL STIMULUS HISTORY

Bruns Patrick, Röder Brigitte

University of Hamburg ~ Hamburg ~ Germany

Vision serves as a reference for recalibrating auditory spatial maps, as exemplified by the ventriloquism aftereffect: After exposure to consistently misaligned audiovisual stimuli, unimodal sound localization is shifted toward the visual stimuli. Recent studies have shown that recalibration does not require accumulated evidence of cross-modal mismatch, but occurs even after one single exposure. It is, however, unknown whether instantaneous recalibration and recalibration based on accumulated evidence represent the same underlying learning mechanism or involve distinct neural systems. To answer this question, we assessed the ventriloquism aftereffect on a trial-by-trial basis. Participants had to localize 750 and 3000 Hz tones, which were either presented alone, or with synchronous visual stimuli displaced 13.5° to the left or right. Importantly, the two different sound frequencies were consistently paired with opposite directions of audiovisual spatial mismatch (leftward vs. rightward). In accordance with this global stimulus history, localization in unimodal auditory trials was shifted in opposite directions for the two sound frequencies. On a trial-by-trial basis, however, this frequency-specific recalibration was reduced when an audiovisual stimulus with a different sound frequency (and thus direction of spatial mismatch) preceded the unimodal test stimulus. These findings indicate distinct learning mechanisms operating at different timescales: Local stimulus history results in instantaneous (frequency-invariant) recalibration; global stimulus history invokes changes in frequency-specific spatial maps typical for early auditory cortex, possibly as a consequence of a repeated and consistent activation of recalibration via multisensory parietal structures.

T6.6 STIMULUS PREDICTABILITY MODULATES PERCEIVED TACTILE INTENSITY

Rohde Marieke, Debats Nienke, Ernst Marc

University of Bielefeld ~ Bielefeld ~ Germany

Tactile suppression is a reduction in tactile sensitivity during movement in humans. This attenuation is at least partially driven by top-down, cortical processes, even though the precise functional role remains unclear. Here, we present results from an experiment to study whether tactile suppression might serve to suppress predictable sensory information during action. We modulated stimulus predictability by varying the overall probability of vibrotactile stimuli to the index finger while participants moved a stylus across a graphics tablet. Participants rated the perceived intensity of stimuli using a magnitude estimation task. Contrary to the hypothesis that predictability might increase the suppressive effect of movement, we found that stimuli were reported as more intense in the predictable condition. This facilitation effect was linear across the range of stimulus intensities we used and occurred for both the moving and the non-moving hand (control condition). In the unpredictable condition, however, the perceived intensity decreased as a function of the number of trials that had passed since the last stimulation trial: The more trials had passed (higher expectancy of stimulation on next trial), the less intense was the perceived stimulus. We conclude that predictability has an effect on perceived tactile intensity but that the mechanism of this are different from tactile suppression, which only occurs during movement and which only works in one direction (suppression).

Talks Session 7: CROSS MODAL INTEGRATION (2)

Tuesday 16th June – Pacinotti Meeting Room 11.30 – 1.00 pm

T7.1 WHAT MULTISENSORY NEURONS LEARN DURING MATURATION DETERMINES WHAT THEY INTEGRATE AND WHICH COMPUTATION THEY USE

Rowland Benjamin{1}, Xu Jinghong{2}, Yu Liping{2}, Stein Barry{1}

{1} Wake Forest School of Medicine ~ Winston-Salem ~ United States, {2} East China Normal University ~ Shanghai ~ China

Multisensory neurons in the superior colliculus (SC) receive signals from multiple visual (V), auditory (A), and somatosensory (S) sources. Experience with co-varying cross-modal cues enables these neurons to integrate these signals using a superadditive/additive operation, appropriately reflecting the complementary nature of the information offered by the different modalities. In the absence of this experience neurons apply an averaging operation to cross-modal signals, whose product is less robust than the best component response. This is typical of how these neurons deal with pairs of within-modal stimuli: they treat them as if they offer redundant signals. Recent studies of trisensory (VAS) superior colliculus (SC) neurons suggest that both operations can be simultaneously implemented and specifically applied to different modality pairings within the same neuron. Neurons in dark-reared animals learned to enhance responses to A-S inputs, but averaged V-A and V-S inputs; noise-reared neurons enhanced V-S responses, but averaged A-V and A-S responses. Thus, the neuron's prior experience predicted which operation would be applied to which modality combination. The magnitude and timing of the responses to the individual cues did not. These observations indicate that multisensory integration neither follows from simple current summation/transduction nor develops according to a general mechanism; rather, its development reflects the adoption of a non-default operation that is applied specifically to modality pairs in accordance with the neuron's experience with cross-modal cues.

T7.2 THE STABILITY AND GENERALIZATION OF MULTISENSORY INTEGRATION ACROSS TIME AND SPACE

Odegaard Brian, Shams Ladan

University of California, Los Angeles ~ Los Angeles ~ United States

Previous studies have revealed a significant amount of variability across individuals' sensory integration tendencies for a given task. For the same set of stimuli, one subject may consistently integrate the stimuli, while another subject may not integrate at all. However, it is not clear what factors underlie this variability; the tendency to integrate could be influenced by genetics, neuroanatomy, experience, or other factors. If the tendency to integrate is influenced by a stable, global mechanism, then one should expect it to be the same across tasks and across time. If it is based on experience, though, one may expect it to be task-specific. To investigate this topic, 59 subjects participated in an experiment involving an audiovisual spatial localization task and an audiovisual temporal judgment task, and then returned one week later to repeat these same two tasks. Using a Bayesian Causal Inference model (Wozny et al., 2010), we quantitatively estimated every subjects' prior tendency to integrate in both tasks in each session to determine whether their binding tendencies were (1) stable across time for each task, or (2) generalized across tasks on a given day. Interestingly, while the binding tendency for each subject was stable over time within one task, this tendency did not generalize across tasks, indicating that spatial and temporal integration processes are not governed by a universal parameter controlling sensory integration. These important, novel findings reveal variability in integration tendencies across space and time, and should inform future investigations probing the domain-specific nature of sensory integration processes.

T7.3 CORRELATION DETECTION AS A GENERAL MECHANISM FOR MULTISENSORY INTEGRATION

Parise Cesare, Ernst Marc

University of Bielefeld ~ Bielefeld ~ Germany

The nervous system efficiently processes multisensory information by selectively combining related signals across the continuous stream of multisensory inputs. However, the fundamental question of how the brain solves the correspondence problem, that is, how it selects which signals to combine, is still awaiting a conclusive answer. Here we propose a novel multi-purpose model for multisensory integration akin to the Reichardt-Hassenstein detector, a classic correlation detector model originally developed for explaining visual motion perception. To validate the model we compared its prediction against human performance in a series of both new and previously published psychophysical results. The model could near-perfectly replicate human responses in several perceptual tasks assessing the temporal constraints of audiovisual integration, and it is flexible enough to process signals of any complexity. Besides solving the correspondence problem, this simple and yet biologically plausible model provides for the first time a unique general explanation for a number of key aspects of multisensory perception. This includes optimal cue integration, breakdown of integration, and the detection of correlation, lag, and synchrony across the senses.

T7.4 A VISUAL-TACTILE VENTRILOQUIST ILLUSION

Samad Majed, Shams Ladan

University of California, Los Angeles ~ Los Angeles ~ United States

Ventriloquism is a well-studied multisensory illusion of audiovisual space in which the perceived location of an auditory stimulus is shifted in the direction of a synchronous but spatially discrepant visual stimulus. This effect is due to vision's superior acuity in the spatial dimension, but has also been shown to be influenced by the perception of unity of the two signals. We sought to investigate whether a similar phenomenon may occur between vision and somatosensation along the surface of the body, as vision is known to possess superior spatial acuity to somatosensation. We report the first demonstration of the visual-tactile ventriloquist illusion: subjects were instructed to localize visual stimuli (small white disks) or tactile stimuli (short vibrations) that were presented concurrently or individually along the surface of the forearm for a total of 455 trials, where bimodal presentations included spatially congruent and incongruent stimuli. Subjects showed strong visual-tactile interactions that were quantified by calculation of tactile bias, which we computed as the localization error as a percentage of the relative disparity. There was also a significant negative correlation between tactile bias and absolute spatial disparity, such that subjects exhibited smaller bias for more spatially discrepant stimuli. These results suggest a causal inference process operating in the brain. We used the Bayesian causal inference model to quantify the precision of each modality, and the tendency for integration in each individual observer. Findings confirmed a strong interaction between the two modalities, and suggest optimal integration of visual and tactile spatial signals.

T7.5 DISSOCIATING VESTIBULAR AND SOMATOSENSORY CONTRIBUTIONS TO SPATIAL ORIENTATION

Alberts Bart{1}, Selen Luc{1}, Bertolini Giovanni{2}, Tarnutzer Alexander{2}, Medendorp Pieter{2}

{1} Radboud University Nijmegen ~ Nijmegen ~ Netherlands, {2} University Hospital Zurich ~ Zurich ~ Switzerland

Knowing the orientation of objects in the environment, commonly referred to as spatial orientation, is important for situational awareness as well as for the planning of goal-directed actions. Spatial orientation is based on the integration of multiple information sources, including visual, vestibular (otoliths) and somatosensory signals. The individual contribution of the various signals is difficult to determine because they cannot be assessed in isolation. Here we used a probabilistic approach to quantify the characteristics and contributions of the individual constituents, assuming they make a reliability-dependent contribution (Clemens et al., 2011). Using a psychometric approach, we measured subjects' (N=10) accuracy and precision in determining the orientation of a briefly flashed line relative to their perceived gravitational vertical (Subjective Visual Vertical (SVV)), for different combinations of whole-body roll tilt angles (-90 to 90 degrees in steps of 30 deg) and head tilt angles relative to the body (-30, 0, 30 deg). Parameters of the probabilistic integrationmodel suggest that 1) otolith information becomes less reliable with increased roll tilt angle and 2) information of the trunk worsens to a tilt angle of about 30º but then becomes more reliable again at larger tilt angles. This implies that we mainly rely on vestibular information around upright, and weight our trunk sensors more heavily at larger roll tilt angles.

T7.6 VISUAL-AUDITORY LOCALISATION IN CENTRAL AND PERIPHERAL SPACE

Garcia Sara{1}, Jones Pete{1}, Rubin Gary{1}, Nardini Marko{2}

{1} University College London ~ London ~ United Kingdom, {2} University of Durham ~ Durham ~ United Kingdom

Normally sighted adults can combine visual and auditory cues to location optimally by weighting each according to its reliability (Alais & Burr, Curr Biol 2004). Here we investigated the extent to which observers take into account natural variations in sensory precision across the visual field. Visual localisation and freefield auditory localisation thresholds deteriorate towards the periphery at different

rates. We assessed whether normally sighted adults continued to combine visual and auditory signals optimally when presented in (i) central (1-17°) and (ii) peripheral (36-53°) space. Nine normally sighted adults (18-30yrs) were presented with blocks of audio-only (100ms white noise burst), visual-only (25ms flash from 5-50 LEDs, spanning 25°) and, audio-and-visual-combined stimuli, in central and peripheral visual fields. On each trial, participants indicated whether the standard (central: 1°; peripheral: 36°) or comparison (+0-16° relative to standard) was further right. Psychometric functions were fitted to these responses. Congruent bimodal trials measured improvements in sensitivity when two cues were available together (via slope), while bimodal trials with ±1° conflicts measured cue weighting (via PSE). Mean visual thresholds deteriorated more in the periphery compared to audio thresholds. Results so far show bimodal performance that is in line with the predictions of an ideal observer model. This suggests that normally sighted adults can account for how their visual and auditory judgments vary in reliability across space. These data will provide a baseline for understanding whether patients with Stargardt's disease (central vision loss) or retinitis pigmentosa (peripheral vision loss) learn to re-weight sensory signals following visual impairment.

Talks Session 8: **TIME**

Tuesday 16th June – Fermi Meeting Room 11.30 – 1.00 pm

T8.1 ALPHA NEURAL ACTIVITY IN THE SOMATOSENSORY AND VISUAL CORTICES: EFFECT OF VISUAL AND PROPRIOCEPTIVE INCONGRUENCE DURING GOAL-DIRECTED HAND MOVEMENT

Lebar Nicolas{1}, Bernier Pierre Michel{2}, Mouchnino Laurence{1}, Danna Jérémy{1}, Moré Simon{1}, Blouin Jean{1}

{1} Laboratory of Cognitive Neuroscience ~ Marseille ~ France, {2} Department of Kinanthropology University of Sherbrooke ~ Sherbrooke ~ Canada

We know that the brain activity in the sensory cortices can dynamically change as a function of the relevance of the sensory input during the planning and control of movements. For instance, the EEG event related desynchronization (ERD) in the somatosensory area around 10Hz (Mu) has been linked to the processing of proprioceptive feedback during movement planning and execution. Besides, the literature shows that comparable ERD could occur in the visual areas (Alpha) for attended visual stimuli. Here we examined neural activity in the somatosensory and visual cortices in a simple hand tracing task, and in a more complex one in which participants received incongruent visual feedback of their tracing hand. Indeed, after a resting condition period (baseline), they had to follow accurately the outline of an irregular shape with a congruent relation between the cursor and the pen movements. Then, after 8-12 s, participants were submitted to a strong (120°) or absent (0°) incongruence between the cursor and the pen. As expected, performance was markedly impaired in the incongruent condition. We used Wavelet time-frequency decomposition to extract Alpha/Mu (8-12Hz) power for each condition. We observed the known ERD linked to movement in somatosensory areas, but no significant ERD in the visual areas. Interestingly, during the incongruent condition, we found a supplementary ERD in the somatosensory cortex (Mu), and also in the visual areas (Alpha). We interpret these results in terms of functionally relevant weighting of somatosensory and visual inputs to deal with sensory incongruence during motor control.

T8.2 NOW YOU FEEL IT, NOW YOU DON'T: ROLE OF PRE-STIMULUS ALPHA OSCILLATIONS IN VISUAL-TACTILE INTEGRATION

Lloyd Donna{1}, Craddock Matt{1}, Poliakoff Ellen{2}, El-Deredy Wael{2}, Klepousniotou Ekaterini{2}

{1} University of Leeds ~ Leeds ~ United Kingdom, {2} University of Manchester ~ Manchester ~ United Kingdom

Fluctuations of pre-stimulus oscillatory activity in the alpha-band (8-12 Hz) observed in human electroencephalography (EEG) influence detection of supra- and peri-threshold somatosensory targets. However, it is unclear whether pre-stimulus alpha power improves detection per se, or influences the overall likelihood of reporting a tactile stimulus even when one is not present. We investigated this relationship in 20 right-handed participants using 64-channel EEG and the Somatic Signal Detection Task (SSDT; Lloyd, Mason, Brown, & Poliakoff, 2008). In the SSDT, participants detect brief (20ms) peri-threshold touches to the index finger of their non-dominant hand. These touches are sometimes accompanied by a simultaneous light flash located next to the index finger, while on other occasions the light flashes but no touch is delivered. We examined pre-stimulus alpha-band activity over somatosensory areas contralateral to the touch stimulus. The results showed that participants successfully detected more touches with a simultaneous light flash than touches presented alone and were more likely to falsely report touch on trials with only a light flash. In the EEG, we found a linear, negative relationship between contralateral alpha-power and reports of touch: As alpha-power increased, participants became less likely to report a touch. Our results show oscillations in the alpha-band over contralateral somatosensory cortex predict reporting of the presence of a tactile stimulus, independent of whether a tactile stimulus is actually presented, which is independent of the general multisensory effect. Furthermore low alpha-power may not necessarily facilitate accurate tactile detection since it also increases the probability of falsely reporting touch.

T8.3 DISTINCT PATTERNS OF LOCAL OSCILLATORY ACTIVITY AND NEURAL CONNECTIVITY UNDERLIE INTERSENSORY ATTENTION AND TEMPORAL ORIENTING

Keil Julian{1}, Pomper Ulrich{2}, Senkowski Daniel{1}

{1} Charité Universitätsmedizin ~ Berlin ~ Germany, {2} Ear Institute, University College ~ London ~ United Kingdom

Knowledge about the sensory modality in which a forthcoming event occurs modulates intersensory attention (IA). Information on when an event occurs enables temporal orienting (TO). Both attention mechanisms can facilitate sensory stimulus processing. Previous studies have separately investigated the neural mechanisms underlying IA and TO. Hence, it is unknown whether IA and TO may interact. In this EEG study we presented a continuous stream of auditory cues, followed by spatio-temporal aligned visuo-tactile stimuli. Auditory cues indicated whether participants should attend to the visual or the tactile input. Moreover, participants were instructed to detect occasional targets in the attended modality. The factor TO was manipulated by presenting stimuli block-wise either at fixed or variable inter-stimulus intervals. EEG data were projected into source space using spatial filtering. We analyzed power, and functional connectivity of frequency transformed data. We computed graph theoretical measures to identify local and global networks underlying IA and TO. Reaction times were faster when stimuli were presented with fixed compared to variable inter-stimulus intervals, demonstrating a facilitating effect of TO. Distinct patterns of local delta-, alpha- and beta-band power modulations and differential functional connectivity in the alpha- and beta-bands, reflected the effects of IA and TO. Local and global network measures revealed attention specific integration and segregation mechanisms. Importantly, theta-band functional connectivity revealed an interaction between IA and TO. We infer that power and functional connectivity of neural oscillations in distributed cortical networks differentially reflect IA and TO. Distinct frequency bands reflect parallel and interacting attention processes.

T8.4 BACKWARDS AND FORWARDS... IN TIME: THE EFFECT OF LOOMING AND RECEDING DANCE STEPS ON PERCEIVED DURATION

Sgouramani Eleni, Vatakis Argiro

Postgraduate Program Basic and Applied Cognitive Science, Department of Philosophy and History of Science, University of Athens, ~ Athens ~ Greece

Our ability to estimate duration has been found to be quite accurate, yet prone to several distortions. For instance, a time dilation has been reported for forward-moving (looming) as compared to backward-moving (receding) stimuli. Such findings have been mostly attributed to potential pacemaker rate changes due to differential arousal levels. Thus, looming stimuli are considered more arousing than receding stimuli, leading to an increased pulse production and accumulation. Time dilation, however, has not always been found, with some studies reporting null effects of looming/receding stimuli in interval timing. Given the conflicting findings and the use of artificial stimulation, we re-examined the issue using the human body as a stimulus in a reproduction task. Specifically, participants watched the video of a dancer moving towards or away from them in a facing or non-facing manner and performing a large or small displacement. Facing was implemented so as to differentiate whether or not the potential time dilation noted was driven by arousal induced by the face or the movement presented. Analysis revealed no effect of direction or facing on duration estimation. However, further analysis of shorter versus longer intervals (short: 960/1200/1440ms; long: 1680/1920/2160ms) showed direction to influence participants' performance for the shorter time intervals tested, with looming stimuli being judged to last longer than receding ones. Thus, raising the probability of an arousing effect of looming stimuli only in short time intervals. This latter finding is further investigated in follow-up experimentation.

T8.5 COARSE RESOLUTION FOR AUDITORY-TACTILE SYNCHRONY DETECTION

Alais David, Orchard-Mills Emily, Van der Burg Erik

University of Sydney ~ Sydney ~ Australia

The brain integrates signals from multiple modalities to provide reliable estimates of external events. Unlike the simple stimuli often used in experimental settings, temporally cluttered event streams pose a challenge for sensory binding yet also have the most potential benefit from cross-modality redundancy (e.g., a crowded noisy room). When a changing visual item is synchronised with a repeated auditory pulse, it is rapidly segregated from other changing visual items, regardless of how many non-synchronised items are present – a striking example of multisensory enhancement known as 'pip & pop'. In contrast, when the cluttered display is presented in the tactile domain using buzzers on each of the fingers, we find search for a vibration pulse synchronised with an auditory pulse is impaired by the addition of vibrations to other fingers, producing poor search efficiency. We show that the temporal limits of binding and segregation in the audiovisual domain are superior to the audiotactile domain, with touch demonstrating poorer temporal resolution and requiring greater separation of tactile events to achieve performance comparable with audio-visual conditions. The results are discussed in the context of the spatial and temporal capacities of vision and touch.

T8.6 SPATIOTOPY-SOMATOTOPY ALIGNMENT IS MULTISENSORY AND INTEGRATED

Noel JeanPaul, Ashmead Daniel, Wallace Mark

Vanderbilt University ~ Nashville ~ United States

The study of the neurobiological processes underlying the spatial localization of touch is critically dependent on coordinate transformations between different reference frames allowing for spatiotopy-somatotopy alignment. Although much work has delineated the body-related characteristics governing such alignment (e.g., body posture), less is known about the features of the realigned space. Thus, in the current study we had participants perform a tactile temporal order judgment (TOJ) task under different sensory environments and body postures. Specifically, participants performed non-speeded judgments about the order to two tactile stimuli presented in rapid succession on their ankles during conditions in which the legs were either crossed or uncrossed. In addition, these judgments were made in the absence of visual, auditory, and combined audio-visual spatial information. As expected based on prior work, results revealed that just noticeable differences (JNDs) were larger under crossed than uncrossed leg postures (regardless of condition). Most importantly, however, results also revealed that auditory and audio-visual deprivation exacerbated this difference in JNDs between uncrossed to crossed leg postures, an effect not seen for visual only deprivation. Furthermore, the effects under the combined audio-visual deprivation were larger than those predicted by the sum of the unisensory auditory and visual deprivation conditions. In sum, these results indicate that interactions between spatiotopic and somatotopic reference frames extend beyond those influenced by body posture, with a heavier weighting of auditory spatial information. Furthermore, the work suggests that the various spatial reference frames (i.e, body-centered, head-centered, eye-centered) are integrated when solving spatial localization judgments.

POSTERS

Posters will be on display throughout the conference. Even-numbered posters should be manned on Sunday morning and Monday afternoon; Odd-numbered posters, on Sunday afternoon and Monday morning.

POSTER SESSION 1: SPEECH AND LANGUAGE PROCESSING

P1.1 SYNCHRONY DETECTION WITH AV SPEECH AND NON-SPEECH STIMULI

Davis Chris, Kim Jeesun

MARCS Institute, UWS ~ Penrith ~ Australia

We used an auditory-visual (AV) synchrony search task to examine how accurately an observer could detect AV synchrony with speech and non-speech stimuli. In this task on each trial a participant viewed four videos (positioned at the cardinal points of a circle) that showed either the lower face of a talker (Expt 1) or a black flood-filled equivalent shape in which mouth opening was white flood-filled (Expt 2) and heard a spoken /ba/ syllable. One of the four videos had the original AV timing and in the others the visual speech was shifted 100 ms, 200 ms or 300 ms earlier. Participants were required to conduct a speeded visual search for the synchronized face/voice token (the position of which was randomized). The results showed that with the AV speech stimuli the synchrony detection window was narrower than that reported with other methods but was broader than the non-speech stimuli. These results are discussed with respect to the salience of the onset of the visual signal.

P1.2 PHONETIC RECALIBRATION OF SPEECH; PARTIAL SPATIAL TRANSFER

Keetels Mirjam, Stekelenburg Jeroen, Vroomen Jean

Tilburg University ~ Tilburg ~ Netherlands

Exposure to incongruent audiovisual speech can recalibrate auditory speech identification, a phenomenon known as phonetic recalibration (Bertelson, Vroomen, & de Gelder, 2003). Repeated exposure to an ambiguous sound intermediate between /aba/ and /ada/ dubbed onto a video of a face articulating either /aba/ or /ada/ (i.e. A?Vb or A?Vd) increases the proportion of respectively /aba/ or /ada/ responses during subsequent auditory-only identification trials. In the present study we examine whether phonetic recalibration is spatially specific. In an exposure-test phase paradigm, participants were exposed to an audiovisual exposure stimulus (A?Vb or A?Vd) presented at one side of the midline and subsequently auditory-only identification stimuli were presented at either that same location, or at the opposite side of the midline. Results indicated that phonetic recalibration effects are strongest at the exact location of exposure, and decline -but are still present- at the opposite side of the midline. Presenting sounds directly at the ear (Experiment 1) or in external space did not change the results (Experiment 2) and neither did crossing the midline (Experiment 3). This study indicates that phonetic recalibration effects are -to a certain degree- spatially specific but do generalize across space. Our results highlight that speech learning is thus very closely tied to the situation encountered.

P1.3 NEURAL CORRELATES OF AUDITORY-SOMATOSENSORY INTERACTION IN SPEECH PERCEPTION

Ito Takayuki{1}, Gracco Vincent{2}, Ostry David{2}

{1} Gipsa lab ~ Grenoble ~ France, {2} McGill University ~ Montréal ~ Canada

Speech perception is known to rely on both auditory and visual information. However, sound specific somatosensory input has been shown also to influence speech perceptual processing (Ito et al., 2009). In the present study we addressed further the relationship between somatosensory information and speech perceptual processing by addressing the hypothesis that the temporal relationship between orofacial movement and sound processing contributes to somatosensory-auditory interaction in speech perception. We examined the changes in event-related potentials in response to multisensory synchronous (simultaneous) and asynchronous (90 ms lag and lead) somatosensory and auditory stimulation compared to individual unisensory auditory and somatosensory stimulation alone. We used a robotic device to apply facial skin somatosensory deformations that were similar in timing and duration to those experienced in speech production. Following synchronous multisensory stimulation the amplitude of the event-related potential was reliably different from the two unisensory potentials. More importantly, the magnitude of the event-related potential difference varied as a function of the relative timing of the somatosensory-auditory stimulation. Event-related activity change due to stimulus timing was seen between 160-220 ms following somatosensory onset, mostly around the parietal area. The results demonstrate a dynamic modulation of somatosensory-auditory convergence and suggest the contribution of somatosensory information for speech processing process is dependent on the specific temporal order of sensory inputs in speech production.

P1.4 THE EFFECT OF SEMANTICS IN AUDIOVISUAL SPEECH SYNCHRONY PERCEPTION

Tsilionis Efthymios, Vatakis Argiro

Postgraduate Program Basic and Applied Cognitive Science, Department of Philosophy and History of Science, University of Athens, Athens, Greece ~ Athens ~ Greece

Face-to-face communication requires the integration of auditory (voice) and visual (lip-facial movements) information of a given speaker(s). Successful integration of audiovisual speech depends on a number of low- and high-level factors (such as synchrony and semantics, respectively). In terms of synchrony, audiovisual speech integration has been found to be tolerant of larger stimulus onset asynchronies (SOAs) as compared to nonspeech signals (i.e., larger temporal window of integration, TWI). One potential theory accounting for this is the ‘unity assumption’ according to which sensory signals that share many ‘amodal’ properties are more likely to be perceived as originating from a common source. Semantics, however, remains a controversial property in integration and so in the present study, we examined both the effect of semantics and temporal synchrony in unity. We hypothesize that the large TWI of audiovisual speech is not only due to low-level characteristics of speech but also of semantics. Thus, words and pseudo-words (two syllables long) were presented audiovisually under various SOA’s in a simultaneity judgment (SJ) task. The stimuli were selected so as not to differ along physical (same temporal structure and complexity) and linguistic dimensions (same phonology). We expect that words will demonstrate a larger asynchrony tolerance, implying that semantics -as a higher-level factor of integration- will promote higher sensory binding and, in turn, lead to larger TWIs. Further experimentation using functional magnetic resonance imaging will allow for the definition of the neural correlates of unity in audiovisual speech.

P1.5 EFFECTS OF A MOVIE OF SPEAKER'S IRRELEVANT SPEECH UTTERANCE ON RECALL TASKS

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A moving image of a speaker's face is useful to understand speech. When listening to speech sounds, relevant visual information in a moving image of the speaker can improve speech intelligibility. In contrast, for serial recall tasks of visually presented digits, irrelevant auditory information might interfere with task performance considerably because of the ""irrelevant speech effect."" This study investigated whether a speaker movie can be used effectively for serial recall tasks with auditory presentation of Japanese digits. Nine digits (1–9) were used; each digit appeared only once. ""Control,"" ""Sound only,"" ""Digit,"" and ""Word"" conditions were set for the experiment. In the “Control” condition, nine Japanese digits consisting of one or two morae were presented aurally via headphones. In the other three conditions, speech sounds of nine Japanese digits and those of Japanese four-mora words uttered by a female speaker were presented. In the Digit and Word conditions, a movie of speaker's face was presented along with the speech sounds. In the Digit condition, the presented movie was that of the speaker uttering the same digit as that of the auditory stimulus. In the Word condition it was that of the four-mora words. Participants were asked to recall all uttered digits. Results demonstrated that the movie including uttering of irrelevant words did not obstruct the serial recall task performance, even when the presented audio-visual signals were inconsistent. These results suggest that a moving image of the speaker's face can be used to segregate the target and interference.

P1.6 LANGUAGE BACKGROUNDS TUNE CROSS-MODAL PERCEPTION BETWEEN LINGUISTIC PITCH AND SHAPE

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Cross-modal correspondences between pitch and visual shape show a high-pointy, low-curvy pattern (e.g., Marks, 1987). How does pitch map to shape when used linguistically, for example in tones of Mandarin Chinese? In a preliminary study (IMRF 2014), Chinese

speakers with different language backgrounds showed subtly different patterns of sound-shape matching for vowels articulated in Mandarin Chinese tones, guided by the dynamic pitch architecture of the tones. In the current study, we replicated the results in a larger, more diverse, online population, comprised of three groups: Chinese dominant bilinguals (C), Chinese-English balanced bilinguals (C/E) and English speakers with no Chinese (E). Participants decided which of two figures (pointy, curvy) was a better match for each of eight sounds: /i/ and /u/ articulated in each of the four tones of Mandarin Chinese. Chinese Speakers: For both groups, we find a significant difference in responses to u, when articulated in the four tones (C/E: $p = .02$; C: $p = .006$). This effect was stronger for Chinese dominant group, and was consistent with our previously described 'Pitch Change Hypothesis'. We also observed significant vowel colour effects (i-pointy u-curvy) for vowels articulated in all four tones (C/E: $p \leq .002$; C: $p \leq .001$). English Speakers: To investigate whether these tone mappings are universal properties of sound symbolic cognition, we compared these groups with non-Chinese speakers, who showed vowel color effects ($p<.001$), but no tone effects. We discuss the interaction between vowel color and tone, and implications for theories about mappings between linguistic pitch and shape.

P1.7 THE MCGURK EFFECT DOES NOT DEPEND ON PERCEPTUAL SYNCHRONY BETWEEN AUDIOVISUAL SIGNALS.

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Temporal proximity between signals from different sensory modalities is one of the most important cues, when integrating them into a single coherent percept. However, the dependence between multisensory integration and subjective synchrony has not yet been revealed. That is, when we perceive synchrony between multisensory events, then are they more likely to be integrated? Recently we reported that occurrence of an audiovisual illusion (bounce percept in stream-bounce display) strongly depends on perceptual synchrony, but is independent from physical temporal proximity between audiovisual events. The present study examined whether such dependence of multisensory binding on perceptual synchrony is also observed in speech perception. We presented pairs of auditory /pa/ and visual /ka/ with various asynchronies. Typically they are fused and perceived as /ta/ in McGurk illusion. For each trial, participants identified phoneme they heard (/pa/, /ta/, or /ka/) and also judged synchrony (synchronous or asynchronous) between the voice and video. The two judgments were made in a random order. We found no significant differences in proportion of /ta/ responses between when audiovisual speech was judged as synchronous and when they were judged as asynchronous. The proportion of /ta/ responses were highest when physical time lag between voice and video was smaller, and decreased as the time lag increased. The results suggest that audiovisual integration in speech perception is independent of perceptual audiovisual synchrony, but depends on physical temporal proximity. This contrasts with the strong dependence of audiovisual binding on perceptual simultaneity in stream-bounce illusion reported in our previous study.

P1.8 ELECTROPHYSIOLOGICAL EVIDENCE FOR AUDIO-VISUO-LINGUAL SPEECH INTEGRATION

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Audio-visual speech perception is a special case of multisensory processing that interfaces with the linguistic system. One important issue is whether cross-modal interactions only depend on well-known auditory and visuo-facial modalities or, rather, might also be triggered by other sensory sources less common in speech communication. The present EEG study aimed at investigating cross-modal interactions not only between auditory, visuo-facial and audio-visuo-facial syllables but also between auditory, visuo-lingual and audio-visuo-lingual syllables. Eighteen adults participated in the study, none of them being experienced with visuo-lingual stimuli. The stimuli were acquired by means of a camera and an ultrasound system, synchronized with the acoustic signal. At the behavioral level, visuo-lingual syllables were recognized far above chance, although to a lower degree than visuo-labial syllables. At the brain level, audiovisual interactions were estimated by comparing the EEG responses to the multisensory stimuli (AV) to the combination of responses to the stimuli presented in isolation (A+V). For both visuo-labial and visuo-lingual syllables, a reduced latency and a lower amplitude of P2 auditory evoked potentials were observed for AV compared to A+V. Apart from this sub-additive effect, a reduced amplitude of N1 and a higher amplitude of P2 were also observed for lingual compared to labial movements. Although participants were not experienced with visuo-lingual stimuli, our results demonstrate that they were able to recognize them and provide the first evidence for audio-visuo-lingual speech interactions. These results further emphasize the multimodal nature of speech perception and likely reflect the impact of listener's knowledge of speech production.

P1.9 AN ASYNCHRONY BETWEEN BEAT GESTURES AND SPEECH AFFECTS LANGUAGE PROCESSING

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Speakers frequently emphasize their message with spontaneous beat gestures tightly synchronized with the speech envelop. Here, we measured BOLD responses from viewers watching a natural discourse where the speaker often used beats to accompany his speech. We hypothesized that beats are thought to arise from a common language system and perceived as a visual equivalent of prosody, and predict that synchrony between beats and pitch accent should have an impact on the activity of brain areas relevant for language processing. We also measured AV synchrony effects when hand beats where replaced with moving discs bearing identical rhythmic and spatial properties. We found that activations in the left MTG/STS and the left IFG were specifically modulated by beat-speech synchrony. In the case of disc-speech, asynchrony modulated the activations in these areas with reversed patterns. These results suggest that listeners may confer beat gestures an additional communicative value (for example speaker's intentions) as compared to simple arbitrary visual cues. We conclude that the emphasizing function of beat gestures in speech perception is instantiated through a brain network sensitive to the communicative intent conveyed by speaker's hands.

P1.10 PREDICTIVE VISUAL MOTION FACILITATES SPEECH PERCEPTION

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Auditory speech is typically accompanied by multisensory cues that enhance the speed and accuracy of auditory perception and can help compensate for degraded auditory processing in the presence of environmental noise or auditory deficits. Research investigating multisensory influences on speech perception has primarily focused on lip articulations during lipreading (speechreading) that provide contextual information for a heard phoneme. However, benefits from multisensory integration are not limited to speech stimuli or to contextual processes, and visual facilitation of speech perception may utilize other multisensory mechanisms. Here we demonstrate a novel form of multisensory facilitation present in natural speech, in which preparatory lip movements enhance phoneme recognition by providing predictive information about the timing of speech-sound onset. Healthy participants were presented with one of four spoken phonemes (/ba/,/ga/,/ka/,/pa/) embedded in noise, and were instructed to report the heard phoneme. Participants experienced a significant accuracy benefit from seeing predictive mouth motion relative to seeing non-predictive mouth motion or hearing auditory speech alone. These results highlight the benefit for speech perception of sound-onset prediction from anticipatory visual motion. In order to examine the role of predictive visual information on auditory neural processes, we acquired intracranial electrocorticographic (ECoG) recordings from patients undergoing evaluation for intractable epilepsy who performed the same task. Indices of local spiking activity were computed from electrodes neighboring auditory cortex. These electrodes showed significantly reduced activity on predictive-motion trials relative to non-predictive-motion or auditory-alone trials, suggesting that predictive visual motion enhances perceptual fluency by reducing auditory processing requirements via reducing temporal uncertainty.

P1.11 SELECTIVE ADAPTATION OF VOCAL SUBJECTIVE SYNCHRONY

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Keio University ~ Tokyo ~ Japan

Prolonged exposure to a temporal gap between multisensory stimuli induces the recalibration of subjective synchrony in audiovisual or sensorimotor modalities. It is known that selective attention toward the temporal structure or non-temporal features of stimuli modulates the recalibration pattern in the audiovisual domain. However, the role of attention toward such temporal and sensory information in the sensorimotor domain remains unclear. We examined how selective attention to temporal and non-temporal information modulates the subjective synchrony in vocalization via synchrony and feature-discrimination tasks involving exposure to vocal-auditory lag. We found that lag exposure with synchrony-oriented attention shifted the point of subjective synchrony in the opposite direction to the lag, while lag exposure with feature-oriented attention induced the regular temporal recalibration. High sensitivity in the synchrony-discrimination task suggests that synchrony-oriented attention made the perceived temporal information unambiguous and thus induced the selective adaptation of vocal subjective synchrony.

POSTER SESSION 2: DEVELOPMENT, PATHOLOGY AND REHABILITATION

P2.12 EVIDENCE FOR AN ABNORMAL TEMPORAL WINDOW OF INTEGRATION IN ADHD: A STUDY ON INDIVIDUALS WITH HIGH AND LOW ADHD TRAITS

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Attention-deficit hyperactivity disorder (ADHD) is the most common neurodevelopmental disorder. It is defined by attentional dysfunction, hyperactive/impulsive behaviour, or both. According to preliminary studies and anecdotal accounts, children and adults with ADHD often report hypo-responsiveness and/or hyper-responsiveness to sensory stimuli. However, surprisingly little empirical work has been conducted to actually test the integrity of multisensory integration in ADHD. The main aim of this study was to examine links

between ADHD symptoms and the temporal aspects of multisensory processing. More specifically, differences in the temporal integration window between participants with low and high ADHD traits were assessed using a simultaneity judgment (SJ) and a temporal order judgment (TOJ) task. In the SJ task, participants with high ADHD traits had a significantly smaller temporal window of integration. No statistically significant differences between groups were found in the TOJ task. This is the first study to identify an abnormal integration window in individuals with ADHD traits. Perceived temporal misalignment of two or more modalities can lead to increased distractibility. An abnormality in the perception of simultaneity could contribute to ADHD symptoms.

P2.13 SUPRAMODAL SPATIAL REPRESENTATION REVEALED BY VISUAL-TO-AUDITORY SENSORY SUBSTITUTION

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Visual-to-auditory sensory substitution is a means to convey visual information through audition, and was originally created to compensate for visual loss; here it was used to investigate spatial representation in sighted. After the required pre-experimental training, across two experiments participants used a sensory substitution device to egocentrically learn a regularly-shaped array of objects and then their spatial memory was tested by a judgement of relative direction task, JRD. In Experiment 1, before the JRD task participants could explore a 'haptic-map' of the array, while in Experiment 2 they could not. We found that, when the haptic-map was provided, participants' performance was more accurate in the trials requiring the use of allocentric spatial representation. This suggests that the spatial information provided by the haptic-map was used to generate an allocentric spatial representation of the array. However, when the haptic-map was not provided participants' performance was more accurate in the trials requiring the use of egocentric spatial representation. This suggests that the spatial representation of the array remained egocentric. These results are in line with previous from studies using visual and somatosensory arrays, thus suggesting that spatial representations arising from different sensory modalities share the same properties.

P2.14 VISUO-TACTILE INTEGRATION IN INDIVIDUALS WITH HIGH AND LOW AUTISTIC TRAITS

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Sensory difficulties are one of the most distressing issues amongst individuals with Autistic Spectrum Disorders (ASDs). It is thought that these individuals face difficulties in combining more complex information from two or more sensory modalities, especially for vision, touch and proprioception. Susceptibility to sensory illusions is a fundamental characteristic of perception, with some uncertainty in reference to the autistic population. The current study involved administering sensory illusions to explore visuotactile integration in a sample of individuals with high and low Autistic- like traits. These sensory illusions were administered using the MIRAGE system that works as a virtual reality device allowing the viewer to see a video image of their own hand in the same location as their actual hand, and allows the experimenter to manipulate the image through tactile and proprioceptive manipulations, that gives rise to very convincing bodily illusions. Furthermore, as this system allows individuals to see and feel their own hands being physically distorted, it enables a greater manipulation of top- down bodily illusions. The results from this study showed that individuals with high AQ scores displayed an overall reduced sensitivity to bodily illusions, as well as enhanced proprioceptive performance in comparison to those with low AQ scores, suggesting that individuals with higher number of self- reported autistic traits rely more on sensory input than the global context of the illusion. These findings may help to form the basis of understanding more complex and abnormal cross- modal interactions involving the somatosensory system often seen in individuals with ASD.

P2.15 ENHANCED CORTICAL CONNECTIVITY FOLLOWING WORKING MEMORY TRAINING – AN EEG STUDY IN CONGENITALLY BLIND INDIVIDUALS

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Neuroimaging studies have reported cross-modal changes following blindness. For example, an activation of the visual cortex in non-visual tasks has been observed for a great variety of non-visual perceptual and cognitive tasks. However, considering the brain as a highly interconnected network, the question arises of whether a recruitment of the sensory deprived cortex per se, or rather the functional integration of sensory deprived areas into task-dependent networks, is related to cross-modal compensation. To answer this question, we experimentally induced plasticity by an extensive working memory training employing an n-back task. Congenitally blind adults and sighted controls, matched in gender, age and, education, were adaptively trained either with voices (group A) or tactile stimuli (group B), or performed a 1-back task with minimal cognitive demand (control group). The EEG sensor space connectivity (imaginary part of coherency) was analyzed prior to and after training during the auditory version of the task. A pre-post comparison of training-related connectivity changes revealed enhanced beta-band connectivity between task-relevant temporal regions and central as well as occipital areas after training but only in the auditory trained group A of the congenitally blind sample. Furthermore, in blind individuals

the observed increase in temporo-central, and temporo-occipital connectivity was positively related to performance. Our results suggest that training resulted in an extension of the task-related working memory network by integrating the deprived occipital cortex. Thus, to understand the full repertoire of mechanisms underlying neuroplasticity, it seems essential to consider large-scale interactions. This study was supported by the German Research Foundation.

P2.16 EXPLORING THE BENEFITS OF ACTION OBSERVATION MIRROR NEURONS PRIMING FOR POST-STROKE HEMIPARESIS REHABILITATIONS

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What if simply watching a video could improve motor performance for post-stroke hemiparetic patients? Hemiparesis is an unheralded motor impairment characterized by a lack of control and sensitivity in the contralateral limb to the brain lesion, which greatly impairs patients' quality of life [1]. Research shows that the Mirror Neuron System (MNS) is implied in motor function and activates similarly both when observing someone performing an action, and when executing action [2]. In the present study, we focused on improving hemiparesis rehabilitation using MNS action observation priming. We compared motor performance of eight upper limb hemiparetic patients before and after an action (video) observation which was either a therapeutic or a control intervention. The results revealed that the therapeutic action observation priming resulted in smoother gestures without motor jerks relative to the pre-observation and control conditions, but there were no effects to motor movement speed. These findings show a new form of rehabilitation material that could provide advances towards the use of more enthralling rehabilitation material for patients, and more ecological and specific ways to provide rehabilitation and assess patients with personalized tests and exercises based on everyday life gestures and activities. [1] Schaechter, J. (2004). Motor rehabilitation and brain plasticity after hemiparetic stroke. Progress in Neurobiology, 73, 61-72. Doi: 10.1016/j.pneurobio.2004.04.001. [2] Rizzolati, G., & Fabbri-Destro, M. (2010). Mirror neuron Mechanism. Encyclopedia of behavioral neuroscience, 240-249. Doi: 10.1016/B978-0-08-045396-5.00212-8.

P2.17 LARGE-SCALE IMBALANCE IN THE BRAIN NETWORK CODING FOR AUDITORY MOTION INFORMATION INDUCED BY EARLY VISUAL DEPRIVATION.

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The extrastriate occipital structure hMT+/V5 is classically considered to implement motion processing from visual inputs only. However, recent studies have suggested the presence of motion-related information from non-visual modalities in this region in blind and sighted individuals. In the present study, we aim to characterize if auditory motion information is represented in hMT+/V5 in both the congenitally blind and sighted individuals using multivariate pattern analysis (MVPA). Brain activity was characterized using functional magnetic resonance imaging while participants listened to pink noise auditory stimuli depicting in-depth motion, horizontal motion, and static sounds. A single multi-class linear support vector machine (SVM) classifier was trained and tested for each subject separately to classify between the response patterns of three auditory conditions. Our results suggest the presence of auditory motion-related information in hMT+/V5 in both groups, but to a significantly higher extend in blind individuals. A whole brain searchlight approach revealed that occipito-temporal region (overlapping with the univariate definition of hMT+/V5) was the only brain region containing enhanced auditory motion information in the blind when compared to the sighted group. Importantly, and in striking contrast with what was observed in hMT+/V5, we observed that more auditory motion information is represented in the auditory cortex (including the planum temporale) of sighted individuals compared to the congenitally blind. These results suggest that early visual deprivation triggers a large-scale imbalance between separate audio-visual brain regions dedicated to the processing of motion information.

P2.18 EFFECT OF SHORT AUDITORY-MOTOR TRAINING ON SPATIAL LOCALIZATION IN BLIND

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We recently showed that visually impaired adults show compromised skills in some complex audio and proprioceptive tasks. An important question is whether an auditory feedback about arm movements may help to improve the impaired spatial perception in early blind subjects. Here we studied the effect of an audio spatial training on the ability to reproduce a hand pointing task toward a moving sound and detect the final location. Forty subjects (16 early blind, 8 late blind, 16 healthy blindfolded controls) performed the same task during two sessions. Between the two sessions a 2 minutes training was performed. This training could be either active, i.e. moving the sound around the body mapping the peri-personal space, or passive, i.e. a complete rest. Subjects were randomized on the two conditions. The spatial accuracy, indicated by localization error and localization bias, was calculated for each participant and for each spatial position. In the first session, contrarily to blindfolded controls and late blind, early blind individuals showed a worse spatial accuracy, presenting impairment on the lower positions of the plane. This impairment wasn't present in late blind. However, after the active training, the spatial accuracy was highly improved ($P>0.05$). No statistical difference was present in case of passive training.

Blindfolded controls or late blind didn't show any enhancement in spatial accuracy in either active or passive training. This result suggests that short audio motor training could improve audio spatial precision in early blind individuals.

P2.19 MULTISENSORY INTEGRATION IN AUTISM SPECTRUM DISORDERS: IMPAIRED BINDING OR IMPAIRED TIMING?

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The question of intact or impaired multisensory processing in Autism Spectrum Disorders (ASD) remains as yet unanswered. Some studies examining low-level multisensory integration -via the double flash- illusion have reported no specific impairment, while others have found the illusion to persist for a temporal window twice the size of that noted in healthy controls. Studies utilizing complex stimuli have found impaired audiovisual integration for speech only, others for both speech and non-speech stimuli, while others have found integration to be no different from that of healthy controls. This ambiguity in current research could have been driven by the population tested (adult vs. children), the severity of symptoms, the stimulus types (social vs. non-social) presented, specific tasks utilized (preferential looking paradigm vs. temporal order judgments), and/or the confound of binding and timing. In our study, therefore, we utilized non-social stimulation in a well-formed group of children with similar symptom severity in two types of tasks: a reaction time (RT) and a simultaneity judgment (SJ) task. Through the RT task, we examined multisensory integration in the ASD group compared to the control group by manipulating informational relatedness rather than timing. While in the SJ task, binding was examined when a timing modulation was implemented. These two tasks together can provide a sufficient first investigation of the status of multisensory integration and/or synchrony mechanisms in ASD.

P2.20 THE ROLE OF AGE ON THE PERCEPTION OF TRAITS FROM YOUNGER AND OLDER VOICES AND FACES.

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Trait information is inferred instantly from person's face and voice (1,2), however the effects of age on making social judgments is unclear. We investigated how observer's age, and observed person's age, affect trait perception from neutral expressive faces and voices. We used images of unfamiliar faces (FACES;3) and short, semantically neutral clips of unfamiliar voices taken from young, middle-aged and older persons. Sixty-one younger (14 males, mean age 22.7 years) and 30 older (13 males, mean age 71.9 years) participants rated each face or voice on a scale of 1('not very') to 7('very') on six cognitive dimensions; attractiveness, competence, distinctiveness, dominance, familiarity and trustworthiness. Face or voice stimuli were presented in separate sessions. Trials were blocked by age and sex. Session order was counterbalanced and block order was randomised across participants. Older adults rated face images higher across all ages compared to young adults. Results revealed attractiveness ratings provided to faces and voices to decrease with increasing age of the stimulus, whereas distinctiveness ratings for voices increased with voice age. Young faces were perceived as more familiar relative to other faces by all participants. The findings suggest that participant's age, and age of the stimulus, affected trait perception with preferences for youthful stimuli. We found no evidence for own-age bias. Our findings extend previous literature on the role of the observer's age on evaluations of faces (4,5) by providing evidence to suggest that age of both the face and voice affects the perception of trait information.

P2.21 EFFECT OF A RUBBER HAND PRESENTATION ON VISUOTACTILE TEMPORAL ORDER JUDGMENT: ASSOCIATION WITH AUTISTIC TRAITS

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Autism-spectrum disorder (ASD) is characterized by atypical processes of sensory information from various types of modality. Recent researches have reported that occurrence of rubber hand illusion was delayed in individuals with ASD. In contrast, their extended audiovisual temporal binding window is also suggested. Ide & Hidaka (2013) showed that the visual presentation of hand image modulates visuotactile temporal order judgment (TOJ) However, it remains unclear whether autistic traits influence visuotactile temporal processing modulated by body representation. Thus, we studied that the autistic traits could influence visuotactile TOJ in the presence of a rubber hand presentation. A visual stimulus was presented on the index finger of the rubber hand which is placed above participant's hidden left hand, while a tactile stimulus was delivered to the index finger of her/his own left hand. Participants ($n = 18$) were required to judge temporal orders of the visual and tactile stimuli. Consistent with the previous study, we found that the temporal resolution degraded when the rubber hand was presented ($P < 0.01$) in participants with relatively low autism-spectrum quotient (AQ) scores (< 29). In contrast, the modulation effects by the rubber hand presentation were decreased with increasing autistic traits. These results suggest that visual presentation of a rubber hand makes difficult to discriminate visuotactile stimuli, and, accordingly,

participants' performance of TOJ degrades. In addition, body representation might have an insignificant effect on visuotactile temporal processing in individuals with ASD.

P2.22 EFFECT OF A RUBBER HAND PRESENTATION ON VISUOTACTILE CROSS-MODAL DYNAMIC CAPTURES: ASSOCIATION WITH AUTISTIC TRAITS

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Visual apparent motion sometimes affects performance of tactile temporal order judgment (TOJ) at moderately short intervals. Meanwhile, we found that a rubber hand presentation in a forward direction enhances this interaction, and a degree of this effect was correlated with autistic traits of each participant. In this study, we investigated effects of the rubber hand presentation in an inverted direction on this cross modal interactions during tactile TOJ. In front of a participant, a rubber hand in an inverted direction was placed above a flat box in one condition, while it was not placed in the other condition. Participant's right hand was always hidden in the box. Participants (n = 12) were required to judge temporal orders of the tactile stimuli to an index finger and a ring finger of their right hands and to ignore visual stimuli from LEDs that were placed on corresponding fingers of the rubber hand (or just placed on the box). When incongruent visual stimuli were delivered, participant's judgment was notably reversed regardless of conditions. However, when the rubber hand in an inverted direction was presented, the participants with large autism-spectrum quotient (AQ) scores showed relatively small reversals ($P < 0.05$). The rubber hand that was not corresponding to one's own hand may inhibit the visuotactile interactions in some participants with large AQ scores in consequence of segregation in body representations. Autistic traits of each participant may affect body-representation-related modulations of multisensory interactions.

P2.23 DETECTION OF TRAJECTORIES AT BIRTH: THE ROLE OF UNI- AND MULTISENSORY INFORMATION.

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Immediately after birth, newborns are introduced within a highly stimulating environment, where many objects move close to them. It would therefore be adaptive for infants to be able to infer the trajectory of those moving objects from multisensory hints. We run a first study aiming at understanding if newborns were able to discriminate between visual objects moving along a colliding versus non-colliding trajectory. Results demonstrated that newborns showed a visual preference for approaching and colliding objects compared with non-colliding ones, both when receding and approaching on a non-colliding trajectory. Crucially, they also looked significantly longer at movements directed towards the Peripersonal Space compared with those directed away from it. A second study aims to further investigate this behavioural preference by addressing whether the use of additional auditory cues could influence newborns' detection of relevant trajectories. Newborns are presented with paired approaching and receding visual movements as in the previous study, but the visual stimuli are accompanied by an approaching or receding sound congruent with only one of the two simultaneous visual events. Preliminary findings suggest that newborns seem to show an enhanced attention towards the approaching visual stimulus when paired with a congruent sound. Conversely, when the sound is receding newborns so far do not appear to show a clear visual preference.

P2.24 ALTERED EVOKED BETA AND GAMMA BAND OSCILLATIONS DURING MULTISENSORY PROCESSING OF THE SOUND-INDUCED FLASH ILLUSION IN SCHIZOPHRENIA

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Recent behavioral and neuroimaging studies suggest altered multisensory processing in patients with schizophrenia (SCZ). The neural mechanisms underlying abnormal multisensory processing in this patient group are not well understood. We addressed whether dysfunctional neural activity, measured by EEG, contributes to altered multisensory processing in SCZ. In 15 schizophrenic patients and 15 non-psychiatric control participants, we examined multisensory processing in the sound induced flash illusion (SIFI). In the SIFI multiple auditory stimuli that are presented alongside a single visual stimulus can induce the illusory percept of multiple visual stimuli. Event-related responses and neural oscillations to illusion and no-illusion trials were compared between groups. The SIFI illusion rates did not differ between patients (55.7 %) and controls (55.4 %). However, groups differed in the comparison between illusion and no-illusion trials in a mid-latency event-related component (108-164 ms) at posterior electrodes. In patients we observed no amplitude differences, whereas amplitudes were larger in illusion than no-illusion trials in controls. Moreover, we found group differences in evoked beta- and gamma-band power. Patients exhibited larger gamma-band power (32-54 Hz; 20-140 ms) to illusion compared to no-illusion trials, whereas controls showed the opposite pattern. The reversed pattern was found for beta-band power (20-30 Hz; 0-200 ms). Thus,

our study revealed that schizophrenic patients exhibit altered multisensory processing of the SIFI, as reflected in abnormal event-related responses and neural oscillations. Since there were no differences in SIFI illusion rates, the observation of altered neurophysiological responses might indicate compensatory mechanisms during multisensory processing in SCZ.

P2.25 NEUROMODULATION AVERTS PHANTOM PAIN AND REINSTATES THE DEPRIVED CORTEX TO THE SENSORIMOTOR SYSTEM

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Following arm amputation vivid sensations of the missing limb are frequently reported. These 'phantom' sensations are often experienced as painful, manifested in an intractable chronic neuropathic pain syndrome (phantom limb pain, PLP). Neurorehabilitation approaches, designed to reinstate the representation of the missing hand into the deprived cortex, are ineffective. We recently showed that chronic PLP magnitude positively scales with maintained representation of the missing hand during voluntary phantom movements, and functional isolation of the deprived cortex. The current study aimed to modulate PLP using non-invasive brain stimulation (neuromodulation), in a double blind, counterbalanced, and sham-controlled design. Twelve upper-limb amputees suffering from chronic PLP underwent twenty minutes of excitatory or sham neuromodulation (transcranial direct current stimulation, tDCS) to deprived sensorimotor cortex while performing a PLP-inducing task. Task-based and resting-state functional magnetic resonance imaging scans, as well as subjective pain ratings, were obtained prior to and post neuromodulation. Whereas PLP was increased in the sham condition, excitatory stimulation of deprived sensorimotor cortex averted this pain increase. PLP induction was seen in conjunction with functional isolation of the phantom hand area from the sensorimotor cortex, demonstrated using resting-state functional connectivity analysis. Prevention of PLP following excitatory neuromodulation was related to a functional reintegration of the phantom hand cortex into the sensorimotor system, as reflected in increased activation in sensorimotor areas during phantom hand movements. By demonstrating the neural consequences of tDCS, our results reveal tDCS as a promising tool for managing PLP and highlight the tight coupling between PLP and the sensorimotor system.

P2.26 ASYMMETRICAL MEDICAL GENICULATE BODY VOLUME IN PEOPLE WITH ONE EYE

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We have previously shown that people who have lost one eye early in life have enhanced sound localization (Hoover et al., 2011), lack visual dominance (Moro & Steeves, 2011) and integrate auditory and visual information optimally (Moro et al., 2013) compared to binocular and eye-patched viewing controls. Structurally, people with one eye have decreased lateral geniculate nuclei volume (LGN; thalamic visual relay station). However, this decrease is less severe in the LGN contralateral to the remaining eye, indicating altered structural development (Kelly, et al., 2013). The medial geniculate body (MGB; thalamic auditory relay station) plays a central role in auditory processing with both efferent and afferent tracts to primary auditory cortex (Schönwiesner et al., 2007). Given the existing audiovisual processing differences and LGN changes in people with one eye, we investigated whether structural MGB changes are also present. MGB volumes were measured in adults who had undergone early unilateral eye enucleation and were compared to binocularly intact controls using the current gold standard methodology for anatomical localization of the MGB (Devlin, 2006). Unlike controls, people with one eye had a significant asymmetry with a larger MGB volume in the left compared to the right hemisphere, independent of eye of enucleation. The volume asymmetry in the MGB in people with one eye may represent increased interaction between the left MGB and primary auditory cortex as compensation for the loss of one half of the visual inputs early in life.

P2.27 AUDIO-MOTOR FEEDBACK CALIBRATES BOTH AUDITORY AND HAPTIC SPACE IN VISUALLY IMPAIRED CHILDREN

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The acquisition of spatial capabilities is driven by the reciprocal influence between visual perception and execution of movements [Bremner et al., 2008]. We recently found that early blind people are severely impaired in both the auditory and the haptic spatial domains [Gori et al., 2012; Gori et al., 2014], suggesting that the absence of this multisensory integration between vision and motion might compromise the spatial development. For this reason, we developed a rehabilitative device for blind people that aims at overcoming these spatial impairments, by replacing the visual with the audio information and providing an audio feedback about body movements (ABBI, Audio Bracelet for Blind Interaction). Ten early blind and ten low vision children participated in a rehabilitation study

in which they used the ABBI device for a total of 65 hours in 12 weeks with both professional trainers (45 minutes per week) and with parents at home (5 hours per week). The evaluation of their spatial performance with psychophysical and qualitative tests before and after the 12 weeks rehabilitation reveals that they overall improve their ability to understand and internalize the structure of the space both in the auditory and the haptic domains. In conclusion, we provide scientific evidence that the audio feedback about body movement provided by the ABBI device is effective in reducing the spatial impairments of visually impaired children.

P2.28 REDUCED DYNAMIC VISUAL CAPTURE IN PEOPLE WITH ONE EYE

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People with one eye integrate the auditory and visual components of multisensory events optimally when determining spatial location (ventriloquism effect; Moro, Harris & Steeves, 2015, MSR). This optimal performance is observed despite previous research showing that people with one eye have enhanced sound localization (Hoover, Harris & Steeves, 2012, EBR) and lack visual dominance (Moro & Steeves, 2011, EBR), commonly found in binocular and monocular viewing controls. Here we investigate how people with one eye perform during the integration of moving signals in depth. Participants were presented with a disk that increased or decreased linearly in diameter to give the impression of a looming or receding visual stimulus paired with an auditory tone that was either congruent (ie. looming visual and looming auditory) or incongruent with the visual stimulus (ie. looming visual and receding auditory). Binocular and patched viewing controls demonstrated a robust dynamic capture effect where the perceived direction of motion of the auditory stimulus was influenced by the direction of the visual stimulus. People with one eye, however, demonstrated a reduction of dynamic visual capture. It is possible that changes in neural connectivity, as an adaptive cross-sensory compensatory mechanism for the loss of binocular visual input may contribute to increased reliance on the auditory modality. This might be an adaptive bias associated with motion cues where an unreliable visual depth cue in this group might not lead to accurate detection of looming motion and consequently might be critical for survival.

P2.29 ENHANCEMENT OF VISUOTACTILE INTERACTION IN OLDER ADULTS WITH POORER SENSORIMOTOR FUNCTIONS: EVIDENCE FROM REDUNDANT TARGET EFFECTS

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Our previous study reported the extension of the space where visuotactile interaction occurs in the older adults who showed poorer performance in the Timed Up and Go Test (TUG) using a visuotactile crossmodal congruency task (Teramoto, Kakuya, & Sekiyama, 2014, IMRF). In order to generalize this specific finding to the other experimental paradigm, the present study investigated visuotactile redundant target effects (RTEs) in a Go/No-go task in older adults (M=73.28 years, N=18). In experiments, tactile stimuli were delivered either to the left or right index finger, while visual stimuli were presented at a distance of 5 cm (near), 37.5 cm (middle) or 70 cm (far) from the finger. Participants produced speeded responses all to randomized sequence of unimodal (visual or tactile) and simultaneous visuotactile targets presented in one hemispace (go trials), while ignoring tactile stimuli presented in the other hemispace (no-go trials). Results showed that reaction times to visuotactile bimodal stimuli were significantly faster than those for the unimodal conditions. In terms of co-activation, for older adults with better TUG performance, the race model prediction was violated (i.e. the co-activation model was supported) for the RTEs observed in the near condition, but not for those in the middle and far conditions. In contrast, for older adults with poorer TUG performance, the race model prediction was violated for all the distance conditions. These findings suggest a close link between sensorimotor functions and the spatial window of integration of visuotactile information in older adults.

P2.30 MULTISENSORY EFFECTS ON SELF-FACE RECOGNITION IN ONE PATIENT WITH ACQUIRED PROSOPAGNOSIA.

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Despite the ease in recognising one's own face, neuropsychological cases show that this automatic process can sometimes be disrupted. Prosopagnosia is a deficit of visual face recognition characterised, in some cases, by difficulties in recognizing also one's own face. Notwithstanding the debilitating effects of prosopagnosia, few studies have attempted to improve face recognition in these individuals. Importantly, previous studies suggested strategies to improve visual face recognition, ignoring the multisensory nature of self-representation. Therefore, in the present study one patient (CC) with acquired prosopagnosia was tested with the aim of investigating whether her impaired visual self-face recognition could temporally be recovered by multisensory processing of one's own face. To this aim CC performed a two alternative forced-choice self-face recognition task before and after 4-min of synchronous and, as control condition, asynchronous multisensory exposure sessions. CC was filmed while being touched on her face or while producing

facial movements. In the synchronous conditions the video was simultaneously played on a screen in front of the patient (as when seeing oneself in the mirror). In the asynchronous condition, a delay was added to the recording, inducing a mismatch between seen and experienced sensorimotor states. Contrary to our predictions, results demonstrated a significant further impairment in self-face recognition after synchronous sessions. Results will be interpreted in the light of current multisensory theories of self-recognition and future directions for the current line of research will be discussed with the aim of implementing an effective recovery strategy for impaired self-face recognition in prosopagnosia.

P2.31 THE EFFECT OF EXPANDED SENSORY RANGE VIA SENSORY SUBSTITUTION DEVICE ON THE CHARACTERISTICS OF VISIONLESS VIRTUAL NAVIGATION

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Mobility training programs for helping the blind navigate through unknown places with a White-Cane significantly improve their mobility. However, what is the effect of new assistive technologies, offering more information to the blind user, on the underlying premises of these programs such as navigation patterns? We developed the virtual-EyeCane, a minimalistic sensory substitution device translating single-point-distance into auditory cues identical to the EyeCane's in the real world. We compared performance in virtual environments when using the virtual-EyeCane, a virtual-White-Cane, no device and visual navigation. We show that the characteristics of virtual-EyeCane navigation differ from navigation with a virtual-White-Cane or no-device, and that virtual-EyeCane users complete more levels successfully, taking shorter paths and with less collisions than these groups, and we demonstrate the relative similarity of virtual-EyeCane and visual navigation patterns. This suggests that additional distance information indeed changes navigation patterns from virtual-White-Cane use, and brings them closer to visual navigation.

P2.32 THE ROLE OF DEVELOPMENT ON CROSS-MODAL INTERACTIONS IN OBJECT CATEGORISATION

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Auditory and visual information have been shown to interact in higher cortical areas to facilitate object identification and categorisation (Taylor et al., 2006; Werner & Noppeney, 2010), yet optimal multisensory integration of object properties appears to emerge relatively late in development (Gori et al., 2008; Nardini et al., 2010). The aim of the current study was to assess the role of development, and potential ageing effects, on cross-modal interactions in object categorisation. Specifically, we used a semantic priming paradigm to assess audio-visual interactions in the categorisation of objects as living or non-living across four different age groups (children, adolescents, young adults and older adults). The effects of visual primes on auditory targets (Experiment 1) and auditory primes on visual targets (Experiment 2) were tested across three priming conditions where the prime was either semantically congruent, semantically incongruent or neutral. The results showed that, regardless of target modality, object categorisation performance was enhanced when the target object was preceded by a semantically congruent prime relative to targets preceded by an incongruent or neutral prime. Moreover, although children were slower and less accurate overall, the results suggested that semantically congruent cross-modal primes enhanced object categorisation performance to a similar extent across all age groups. However, there was some suggestion for a cost in categorisation performance with semantically incongruent primes in the older groups only. Our results suggest that higher-level cross-modal interactions are present in childhood but that ageing can affect the efficiency with which cross-modal information is combined for object recognition.

P2.33 VISUAL, AUDITORY, AND VISUO-AUDITORY EMOTION PERCEPTION IN CONGENITALLY, EARLY, AND LATE DEAF COCHLEAR IMPLANT USERS

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The perception of affective prosody has rarely been investigated in cochlear implant (CI) users yet. As auditory and multisensory functions are probably shaped during early sensitive periods, we hypothesized that congenitally deaf CI users as compared to CI users with early (<3 years of age) or late deafness onset show lower affective prosodic discrimination and that they preferentially rely on the visual input when presented with audio-visual emotional stimuli. In the present study, congenitally deaf (CD; n=8), early deaf (ED; n=6), and late deaf (LD; n=13) CI users and three groups of age- and gender-matched healthy control participants performed an emotion discrimination task with unimodal visual and auditory as well as audio-visual emotionally congruent and incongruent speech stimuli. In different tasks, participants attended to either the faces or the voices. Across all conditions, performance in the voice task was worse in all CI groups relative to their controls. The CD CI users performed additionally overall worse than their controls in the discrimination of face expression. The control groups gained from congruent crossmodal stimulation in both the face and the voice task. In the CI groups,

however, the discrimination of facial expression was not affected by concurrent voices, whereas prosodic discrimination was modulated by both congruent and incongruent facial information. These results suggest a higher reliance on facial expressions in the perception of emotions due to lower affective prosodic discrimination capabilities in CI users irrespectively of the age-of-onset of deafness.

P2.34 CATEGORISATION OF HANDS AND TOOLS IN AMPUTEES DEPENDS ON PROSTHETIC LIMB USAGE

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Upper limb amputation results in changed interactions with the environment, both through hand actions and artificial limbs (prostheses), which are prominent tools to supplement hand function. We aimed to assess the relationship between adaptive motor strategies and hand/tool cognitive dissociation. To dissociate between hand and tool conceptual categorisation, we developed a novel negative priming paradigm (NP, slowed responses for matched prime and probe), showing a significant interaction between prime (hand/tool) and probe (hand/tool) in two--handed control participants. In contrast, individuals with congenital or acquired hand-loss (n=24) did not show this interaction as a group, however age at amputation correlated with the NP effect (people who lost their limbs earlier in life showed smaller hand/tool dissociation). This could be driven by (in)experience of having a hand, or increased reliance on tools to supplement hand loss. We next studied the effect of prosthetic limb daily usage on hand/tool dissociation. We found a strong trend towards a negative correlation between prosthesis usage and the size of the hand/tool NP effect, suggesting that prosthesis usage contributes to a reduced dissociation between hands and tools. We next predicted that prostheses should yield usage--dependent NP when coupled with a tool probe. Indeed, prosthesis usage positively correlated with prosthesis priming to tool probes, suggesting that people with higher prosthesis usage may categorise prostheses as tools. Our findings suggest that experience contributes to the conceptual categorisation of hands and tools, as exemplified in decreased hand/tool dissociation with hand--loss and increased prostheses/tool association based on prosthesis usage.

P2.35 PROSTHETIC LIMB USAGE RELATES TO ENHANCED VISUAL PROCESSING AND VISUO-MOTOR FUNCTIONAL CONNECTIVITY IN HAND-SELECTIVE CORTICAL REGIONS

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Arm amputation introduces both a change in individuals' ability to interact with their environment and in brain organisation. Here we studied how prosthetic limb usage affects representations of prostheses in the lateral occipitotemporal cortex (LOTC). We predicted that daily prosthetic limb usage would increase prosthesis representation in hand-selective regions of the visual cortex, and increase functional connectivity between visual and motor hand regions. We presented images of upper limbs, functional and cosmetic prosthetic limbs to 32 individuals with acquired or congenital upper limb loss during an fMRI scan. We found a significant positive correlation between prosthesis use and activation in response to functional and cosmetic prostheses, which was localised to LOTC. These clusters overlapped with hand-selective regions, as confirmed using a participant-specific region of interest (ROI) analysis. We also investigated functional connectivity during resting state scans by placing a seed region in the territory of the missing hand in primary sensorimotor cortex (deprived cortex). We found a significant positive correlation between prosthesis usage and connectivity between the deprived cortex and visual hand-selective regions, in whole-brain and ROI analyses. Lastly, we found correlations between connectivity with the deprived cortex and prosthesis-activation in the LOTC. Our findings suggest that habitual behaviour in the form of prosthetic limb use can shape how high-level visual cortex interacts with sensorimotor cortex in order to represent visual information. These findings provide insight into the mechanisms of embodiment, which may aid in developing neurorehabilitation strategies for successful prosthetic limb usage following amputation.

P2.36 VISUAL BIAS DURING VISUO-PROPRIOCEPTIVE CONFLICT INCREASES WITH AGE

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Forming an accurate representation of the body and its location in space requires successful integration of sensory information. Optimal integration is achieved by weighting each source according to its reliability in the given context (van Beers et al., 1998, 1999). Under

conditions of visuo-proprioceptive conflict, erroneous visual information can bias the felt position of a limb, leading to mislocalisation of the body part (Holmes, Crozier & Spence, 2004). Few studies have investigated how children integrate information under such conditions (Bremner et al. 2013). The current study used an adaptation procedure that created a discrepancy between the seen and real location of the right hand in a sample of adults and children. Unaware of the manipulation, participants estimated the felt position of the index finger of both hands without vision. As expected, in adults, right-hand proprioceptive estimates were displaced significantly towards the visual representation of the hand and drifted closer to the real location of the hand over time. Developmental data showed that younger children reported the location of the right hand to be closer to its real location compared to older children and adults, indicating a difference in the weighting of vision and proprioception. Under conditions of visuo-proprioceptive conflict, the bias of sensory weighting towards vision increases during childhood.

P2.37 RESHAPING SENSORY RELIANCE WHEN SENSORY SYSTEMS DECLINE: EFFECT OF AGING ON KINESTHESIA

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To perceive self-hand movements, the CNS relies on multiple sensory information mainly derived from vision, touch, and muscle proprioception. However how and to what extent the CNS relies on these sensory systems to build kinesthetic percepts when they all decline such as when aging? Illusory sensations of right hand rotation were induced by stimulating separately these three modalities at two intensity levels. A mechanical vibrator applied to the pollicis longus muscle, a textured disk and a visual pattern rotating under the participant's hand activated muscle proprioception, touch and vision, respectively. The perceptual responses of 19 healthy elderly adults (60-82 yrs) were compared to those of 12 young adults. In the young group, the three kinds of stimulation elicited similar kinesthetic illusions at each intensity level applied. Compared to those in the younger group, the same levels of stimulation applied in old adults elicited more salient and faster illusions for visual and tactile conditions but the illusions onset latency increased gradually with age. In contrast, the vibration-induced illusions were significantly less frequently evoked, less salient and more delayed in older adults. Lastly, for the three modalities confounded, increasing the intensity level of stimulation resulted in a smaller increase of illusion velocity in old adults than in young adults. This study shows that reliance on sensory inputs for kinesthetic purposes is profoundly reshaped as early as 60 years old. Older people rely more on visual and tactile afferents for perceiving self-hand movements than young adults due to a relative greater muscle proprioception impairment.

P2.38 IMPAIRED AUDIO SPATIAL TUNING IN BLIND HUMANS: A BEHAVIOURAL AND ELECTROPHYSIOLOGICAL STUDY

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The role that visual information plays in the development of spatial auditory abilities is still matter of debate. Several studies have demonstrated enhanced auditory processing in the blind, suggesting that they compensate their visual impairment in part with greater sensitivity of the other senses (Lessard et al., 1998; Roder et al., 1999). However, in previous studies (Gori et al., 2013) we have shown that early visual deprivation can impact negatively on auditory spatial localization: specifically, blind humans seem to have strong impairments for bisecting space in auditory tasks. Here we investigate possible neural correlates of these impaired spatial skills: we study cortical activations by comparing behavioural and electrophysiological parameters reflecting spatial and temporal perception in congenitally blind and normally sighted. In particular, we test the hypothesis that, also when considering neural activations, visual deprivation might more affect the processing of spatial than temporal information provided through acoustic stimuli. On one side, we confirm what we previously reported (Gori 2013): blind participants displayed high spatial bisection abilities, but not temporal, that were inferior to those of sighted controls. On the other side, electrophysiological data reveal differences in the scalp distribution of brain electrical activity between the two groups reflecting lower tuning of early spatial attention mechanisms in the blind subjects. Therefore, joint differences observed in both behavioural and electrophysiological suggest that compromised functionality of brain areas in the blind may contribute to their impaired spatial skill for audio space bisection.

P2.39 HEARING BY EYE: DOES AUDITORY DEPRIVATION WEAKEN OR ENHANCE VISUAL SPEECH PERCEPTION? A PRELIMINARY STUDY IN ITALIAN PROFOUNDLY DEAF INDIVIDUALS.

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Recent studies suggest that seen speech impacts on what is heard by providing complementary information to audition and partly duplicating information about articulatory dynamics. The extent to which the lack of early auditory phonological and articulatory

experience affects the development and efficiency of lip-reading abilities still remains unclear. Only few studies have addressed this question in deaf individuals and no consistent observations have been reported so far. Here we present preliminary results of a newly developed test of lip-reading in the Italian language (LipIT). The LipIT test has been designed to assess lip-reading abilities in both Italian adults and children by reducing potential confounds such as level of literacy and lexical knowledge.The test implements single-word and sentence discrimination subtests and participants are asked to participate in a video-to-picture matching task with multiple-choice responses. At present, 12 hearing and 9 congenitally deaf individuals have completed the whole test, while additional 19 hearing individuals have completed the single-word subtest only. Preliminarily, deaf individuals outperform hearing individuals in single-word but not in sentence discrimination as reported in previous studies. Female participants discriminates words significantly better than male participants. There is no significant correlation with non-verbal IQ, age and years of education. Although a larger sample is needed, our results seem to confirm previous findings of comparable to better word lip-reading skills in deaf individuals. This observation might reflect a compensatory mechanism by which visual speech perception skills are not only preserved but even enhanced as a result of the lack of early auditory phonological experience.

P2.40 AUDIOVISUAL SENSORY BINDING AND SPATIAL LOCALIZATION IN AMBLYOPIA

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Introduction: Amblyopia is a visual impairment caused by abnormal visual experience in childhood. Previously considered a low-level sensory disorder, higher-level perceptual impairments are now recognized. This study explores the spatiotemporal characteristics of audiovisual sensory binding, and uses the Ventriloquism Effect to determine the contributions of audition and vision to spatial localization judgements in amblyopia and visually normal controls. Methods: Participants with amblyopia (n=7) and normal controls (n=16) judged simultaneity of acoustic and visual signals at 13 levels of signal onset asynchrony (SOA), and judged co-localization of acoustic and visual signals at 9 levels of horizontal spatial separation. The point of subjective equality and spatial localization precision for unimodal (auditory and visual) and bimodal (audiovisual) stimuli were determined using a 2-AFC task. Auditory stimuli were clicks, with position controlled by interaural level difference. Visual stimuli were Gaussian blobs, with reliability controlled by blob diameter. All experiments were done viewing binocularly. Results: Participants with amblyopia perceived audiovisual simultaneity more frequently than normal controls over the range of SOA tested (p=0.006). Measures of unimodal and bimodal spatial localization precision were lower in participants with amblyopia than in normal controls across Gaussian blob sizes. Localization precision for bimodal stimuli was better than that for the component unimodal stimuli in both groups. Conclusion: Participants with amblyopia have diminished ability to detect audiovisual asynchrony and reduced precision in visual spatial localization, even when viewing binocularly. Similar to visually normal controls, however, they combine visual and auditory spatial signals to enhancing localization precision of bimodal stimuli.

P2.41 THE ASSOCIATION BETWEEN AUTISM ASSOCIATED POLYMORPHISM ON CNTNAP2, BRAIN STRUCTURAL CONNECTIVITY AND MULTISENSORY SPEECH INTEGRATION

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There is considerable variability in the ability to integrate heard and seen speech. We recently showed that children with autism spectrum disorder (ASD) under the age of 12 show severe deficits in the integration of audiovisual word stimuli. A possible source of this deficit may be aberrant white matter connectivity, which has repeatedly been shown in ASD. A key question is to what extent differences in white matter connectivity are determined by ontogenetic developmental history and how much of that variability can be accounted for by genetic predisposition. CNTNAP2, a gene on chromosome 7 encoding a cell adhesion protein (Caspr2) of the neurexin superfamily, has been suggested to confer ASD risk and has been associated with language acquisition. We hypothesize that some of the phenotypic variability in multisensory integration has genetic origins and is mediated by structural white matter connectivity. In this study we investigated the relationship between genotype of a single nucleotide polymorphism (SNP: rs7794745) at the CNTNAP2 locus on chromosome 7, structural white matter connectivity as assessed by diffusion tensor imaging (DTI) using tract based spatial statistics (TBSS), and performance on a multisensory speech integration task in a cohort of neurotypical adults. We found significant group differences between risk and non-risk carriers in audiovisual performance and widespread differences in fractional anisotropy (FA) in white matter tracts as well as significant correlations between audiovisual performance and FA. Our findings provide novel insights into genetic and neurobiological sources of inter-individual variability in multisensory integration.

P2.42 THE POSSIBLE ROLE OF SEROTONIN SIGNALING IN MULTISENSORY INTEGRATION: IMPLICATIONS FOR AUTISM

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Autism spectrum disorders (ASD) are complex neurodevelopmental disorders characterized by the presence of repetitive/restrictive behaviors and impairments in both communication and social behaviors. In addition, sensory impairments have been consistently observed, with growing evidence that these impairments extend to the integration of multisensory stimuli. The purpose of this study was to evaluate basic aspects of sensory and multisensory processing in a mouse model that recapitulates many of the phenotypic characteristics of ASD. A rare variant in the serotonin transporter has been associated with autism in human subjects, and mice expressing this variant exhibit changes in domains such as social communication and repetitive behaviors. In the current study, animals were trained to respond to auditory and visual stimuli and the benefit of paired audiovisual stimuli on performance was examined. Wild type mice exhibited significant gains in response accuracy under multisensory conditions, with maximal gains seen for stimuli of 500 ms and 300 ms duration. In contrast, mutant animals failed to exhibit performance gains under multisensory conditions, despite being able to learn the auditory and visual tasks in an equivalent manner. Therefore, the results represent the first behavioral study to demonstrate and characterize atypical multisensory processing in a mouse model that recapitulates a number of autism characteristics.

P2.43 A SYSTEM TO PROVIDE A USER AN ARTIFICIAL OCULOMOTOR FUNCTION TO CONTROL DIRECTIONS OF BOTH EYES INDEPENDENTLY BY USING NATURAL USER INTERFACE

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We previously developed a system, “Virtual Chameleon”, that provide independent fields of view to both eyes of a human user, and performed fundamental experiments to investigate human performance and state of user’s vision. In addition, we focused on influence of saccadic eye movements on visual perception with binocular rivalry, and built trackball device into the system to make users control the system in various styles attitude control of camera platforms such as saccade movements, smooth movements and pursuit movements. Results of experiments showed that the user could look around and distinguish independent views as previous work and the implementation of the functions to generate various types of eye movements improved the delay of up to 32.4% on 7 subjects. It was suggested that the function to switch control timing of the system and generate saccadic eye movements improve human performance with user of Virtual Chameleon. Binocular rivalry occurs to the user by using the system. Operation procedures of the system include motor behaviors to hold sensors with both hands and move user’s fingers and arms. These motor behaviors generate not only visual stimuli but also transitions of direction of visual attention by motor senses. It was assumed that transitions of visual attention by motor sense affect the human performance during use of the system. In this study, we introduced a natural user interface to the system to exclude motion sense induced by grasping and finger behavior from the operation of the system.

P2.44 THE MULTISENSORY SUBSTITUTION DEVICE: REPLACING VISION WITH MULTISENSORY PERCEPTION.

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Congenitally blind people exhibit cross-cortical plasticity; that is, neurons in the occipital lobe, normally devoted to vision, respond to auditory and tactile stimuli. This has been observed with the use of sensory substitution devices that transform images into, for example, sounds (the vOICe), or into vibrations on the tongue (Tongue Display Unit – TDU). These devices, and the plasticity they enable, are meant to help people with visual loss navigate in their environment. Although, the learning curve of these devices is generally very slow, and the spatial acuity is very coarse. Our hypothesis is that these limitations are due to the uni-sensory feedback provided. Thus, Multisensory devices should be easier to learn to use, and should also result in a better spatial acuity because of the availability of redundant information. In this experiment, we set out to improve training and acuity with a new “user-friendly” device: The Multisensory Substitution Device (MSSD), combining the vOICe with the TDU. To test its efficiency, we trained participants to recognize shapes and letters either with audio alone, solely through touch, or with both simultaneously. Learning curves were analysed by measuring the time it took them to recognize alphabet letters, and we compared their spatial acuity before and after training using a grating orientation detection task. Here, we present a comparison of the efficiency of auditory, tactile, and multisensory devices, and discuss the suggestion that the MSSD may replace vision and improve rehabilitation in the blind.

P2.45 ALTERED MULTISENSORY TEMPORAL BINDING WINDOW IN OBESITY

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Obesity has been associated with decreased performance on cognitive tests, including abstract reasoning, visuospatial organization, and attention. However, recent evidence suggests that alterations of unisensory and multisensory processing are also present. The aim of this study was to compare the temporal features of multisensory integration in twenty obese people to those of twenty healthy controls, by measuring the audio-visual temporal binding window, defined as the range of stimulus onset asynchrony in which multiple sensory inputs have a high probability of altering responses. Results revealed an extended temporal binding window in obese participants as compared to healthy controls, suggesting an alteration of multisensory binding. An explanatory hypothesis would regard the effect of the chronic low-grade inflammatory state, clinically observed in obesity, on neural activity. We speculate that pro-inflammatory cytokines, which are overexpressed in obesity, alter the temporal structure of the ongoing brain activity. This, in turn, impacts on the neural mechanisms enabling multisensory integration. We believe that our finding sheds new light on the link between the brain and the immune system, and it has potential implications for future experimental design and therapeutic implementation in obesity treatment.

P2.46 SUCCESSFUL USE OF THE EYEMUSIC, VISUAL-TO-AUDITORY SENSORY SUBSTITUTION DEVICE, BY BLIND ADULTS IN NOISY ENVIRONMENTS

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Visual-to-Auditory Sensory Substitution Devices (SSDs) transform visual images into auditory soundscapes. Despite the rehabilitative potential of this method for both visually impaired and blind individuals, it has not yet been widely adopted for everyday use. This is due to various reasons; amongst them are the desire of blind individuals to keep their auditory pathway open, and their disbelief in their ability to inhibit background noise during interpretation of the Visual-to-Auditory SSD input. To address this issue, we compared both accuracy and response times of 10 blind users of the EyeMusic Visual-to-Auditory SSD in two separate conditions; silent, or with background noise from real-life situations. The EyeMusic conveys information related to shape, location and color in a relatively pleasant manner for the users. Participants were tasked with identification of either shapes, colors or the combination of the two features. The EyeMusic input was delivered via bone-conduction, thus keeping their auditory pathway open. Background noise was delivered through loudspeakers positioned in front of the participants. The success rate in each of the tasks in both conditions was over 90%, and response times were less than 2.5 seconds. Although the participants described the background noise as disturbing, crucially, no significant differences emerged between the two conditions for any of these two dependent variables. These findings suggest that visual-to-auditory SSDs can indeed be used in noisy environments and that users can successfully inhibit background noise while correctly interpreting the received input.

P2.47 CROSS-MODAL TIME PERCEPTION, VISUAL NUMBER AND ATTENTION IN VERY LOW BIRTH WEIGHT CHILDREN

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Premature birth has been associated with damage in many regions of the cerebral cortex, although there is a particularly strong susceptibility for damage within the parieto-occipital lobes (Volpe, Lancet Neurology, 2009). As these areas have been shown to be critical for both visual attention and magnitude perception (time, space and number), it is important to investigate the impact of prematurity on both the magnitude and attentional systems, particularly for children without overt white matter injuries, where the lack of obvious injury may cause their difficulties to remain unnoticed. In this study, we investigated the ability to judge time intervals (visual, audio and audio-visual temporal bisection), discriminate between numerical quantities (numerosity comparison), map numbers onto space (numberline task) and to maintain visuo-spatial attention (multiple-object-tracking) in school-age preterm children (N29). The results show that various parietal functions may be more or less robust to prematurity-related difficulties, with strong impairments found on time estimation and the attentional task, while numerical discrimination or mapping tasks remained relatively unimpaired. Thus while our study generally supports the hypothesis of a dorsal stream vulnerability in children born preterm relative to other cortical locations, it further suggests that particular cognitive processes, as highlighted by performance on different tasks, are far more susceptible than others.

P2.48 REDUCED RAPID AUDIOVISUAL RECALIBRATION IN AUTISM SPECTRUM DISORDER

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Autism spectrum disorders (ASD) are characterized by impairments in social cognition, but are also associated with abnormalities in sensory and perceptual processing. Several groups have reported that individuals with ASD show reduced integration of socially relevant audiovisual information, and it has been suggested that this contributes to the higher-order social and cognitive deficits observed in ASD. Here we study audiovisual processing in ASD, using a newly devised technique that studies instantaneous adaptation to audiovisual asynchrony. Adult participants (both with ASD and typically-developing controls) were presented with sequences of brief visual and auditory stimuli, varying in asynchrony over a wide range from auditory-lead of 512 ms to auditory-lag 512 ms. They judged whether the sequence seemed to be synchronized or not. We divided the data into trials preceded by an auditory-lead condition and those preceded by auditory-lag, and fitted gaussian functions to the probability of perceived simultaneity. Typical adults showed strong adaptation effects: the peak of the simultaneity curves for the two sets of data were shifted in the direction of the sign of the preceding trial: trials preceded by an auditory-lead need more auditory-lead to seem simultaneous than those proceeded by auditory-lag, implying strong adaptation (as reported by Van der Burg and Alais). However, observers with ASD showed very weak adaptation, although the simultaneity curves were as narrow as the typical adults. Rapid audiovisual recalibration could be fundamental for the optimization of speech comprehension. Deficits in online recalibration could render language processing more difficult in individuals with ASD, hindering communication.

P2.49 SHORT-TERM MONOCULAR DEPRIVATION MODULATES EARLY VISUO-HAPTIC INTERACTIONS DURING BINOCULAR RIVALRY

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It is well known that the visual cortex of blind subjects is recruited for the processing of auditory and tactile signals, reflecting cross-modal plasticity. However, it is not clear whether cross-modal plasticity occurs in the typical brain. We investigated this issue by testing whether short-term monocular deprivation (MD, which has been shown to strengthen the deprived-eye) modulates the interaction between vision and touch during binocular rivalry. We asked subjects to actively explore a haptic grating while viewing binocular rivalry between orthogonal gratings. At each touch period, we manipulated the orientation of the haptic grating to be parallel to either one or the other visual grating. We tested this visuo-haptic interaction before and after 150 minutes of MD, during which observers wore a translucent eye-patch over one eye. In line with previous reports, we found that haptic stimulation interacted with vision during rivalry both by prolonging dominance and by shortening suppression of the visual stimulus parallel to the haptic one and that MD increased dominance of the deprived eye. Interestingly, after MD the effect of touch was greater on the non-deprived eye, which was strongly suppressed by the other eye, indicating that touch was more effective on the weaker visual signal. This MD-induced modulation of the cross-modal interaction lasted up to 60 minutes after eye-patch removal. These results demonstrate a high degree of cross-modal plasticity in the adult typical visual cortex, pointing to the existence of cross-modal connections to early visual areas.

P2.50 PERCEPTION OF GRASPING BIOLOGICAL MOVEMENT IN CHILDREN WITH TYPICAL DEVELOPMENT AND WITH CEREBRAL PALSY

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Biological motion selectively activates a region in the posterior superior temporal sulcus (STSp), an area frequently affected in subjects with periventricular leukomalacia (PVL), a congenital brain damage of the white matter, often inducing neuromotor impairment involving the lower limbs and, less frequently, the upper limbs. This study investigates how efficiently children and adolescents with typical development (5-18 years old) and children and adolescents with PVL and cerebral palsy (CP) (spastic diplegia and tetraplegia) can derive the shape of the object (a cylinder and a cube) by observing in egocentric and allocentric perspectives a grasping biological motion sequence (see Campanella et al., 2011). The results were correlated with both the extent of the lesion and the motor impairment of the upper limbs. One hundred and ten subjects with typical development and twelve children with PVL and CP but normal Verbal IQ were tested. The results show that PVL children perform significantly worse than controls, and have no systematic preference for egocentric compared with allocentric perspective, as observed in controls. The impairment was equally high for children with upper or lower limb motor impairment, indicating that the perception of grasping biological motion is not correlated with the subject's motor

performance. The same subjects also showed reduced sensitivity to flow-motion discrimination. Taken together, these data indicate that STS cortex representing biological and flow motion may be compromised in children with PVL.

P2.51 SUPRAMODAL MIRROR AGNOSIA IN PATIENTS WITH PERIVENTICULAR LEUKOMALACIA

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Periventricular leukomalacia (PVL) is characterized by focal white matter necrosis due to a hypoxic ischemic event often observed in preterm infants. PVL is frequently associated with motor impairment and with visual deficits affecting primary stages of visual processes as well as higher visual cognitive abilities. Here we describe five PVL subjects, with normal IQ and visual contrast sensitivity, showing orientation perception deficits in both the haptic and visual domains. The subjects were asked to compare the orientation of two stimuli presented simultaneously or sequentially, using both a matching and a 2AFC orientation-discrimination procedure. The visual stimuli were oriented gratings or bars or collinear short lines embedded in a random pattern. The haptic stimuli consisted in a pair of bars. PVL patients performed at chance in discriminating the oblique orientation both for visual and haptic stimuli. Moreover when asked to reproduce the oblique orientation, they often oriented the stimulus as its symmetric mirror. The deficit cannot be explained by simultaneous agnosia nor by impaired visual memory: it also occurs for sequential presentations, but not for horizontal or vertical stimuli. One of these patients was also examined by fMRI, where second-order visual stimuli were presented to peripheral view. In control subjects, area V3A was orientation-selective for the second-order pattern, while the PVL patient showed an anomalous selectivity for the oblique orientation that was consistently confused with the mirror image. These findings show that PVL can affect a specific network involved with supramodal perception of mirror orientation.

P2.52 MIRROR-TOUCH SYNAESTHESIA AFTER BRAIN DAMAGE

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People affected by mirror-touch synaesthesia reported that the sight of a touch on another person elicits tactile experiences on their own bodies. Recently, by using non-invasive brain stimulation techniques, the emergence of synaesthesia-like effects has been described in non-synaesthetes. Here, starting from a neuropsychological perspective, we asked whether synaesthesia-like phenomena may also emerge after a brain damage. We tested 15 brain-damaged (BD) patients and 22 healthy non-synaesthetic controls with a vision–touch interference task typically used for measuring mirror-touch synesthesia: participants viewed an index finger touching a hand-model (left/right), seen from an egocentric or allocentric perspective, while simultaneously receiving a spatially congruent or incongruent touch on their own hand; in the control condition, the index finger only approached the hand-model without touching it. Synaesthetes are typically less accurate and slower at identifying the site touched on their body, when the actual touch is spatially incongruent with the viewed touch (incongruent trials). Here, we found that, as compared to controls, the view of a spatially incongruent touch increase the error rate in BD patients when the actual touch is delivered to the patients' affected (contralesional to the hemispheric lesion) hand, thus suggesting the emergence of synaesthesia-like effects after a brain damage. These effects only pertain to the egocentric perspective, where the anatomical mapping of the observed touch was facilitated. The present findings contribute to our understanding of the causal relationship between the brain-functioning and a crossmodal experience, like the mirror-touch synaesthesia.

P2.53 SUPRANORMAL VISUAL ATTENTION IN SOMATOSENSORY-IMPAIRED SUBJECTS

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Previous research has shown that blind individuals have supranormal abilities in tactile discrimination (van Boven et al. 2000), which is presumably linked to the fact that cortical reorganization in blind leads to the so-called visual cortex to process tactile information (Sadato et al. 1996; Cohen et al. 1997). What would happen to individuals devoid of tactile and proprioceptive information? There is ample evidence that cross-modal plasticity can result in enhanced perceptual abilities in impaired individuals compared to healthy subjects. This idea stems for instance from studies on blind but also deaf individuals, who have enhanced visual abilities (Bavelier et al. 2006; Lomber et al. 2010). Here we tested the visual perception of two patients with massive yet specific loss of touch and proprioception, using the most classic clinical test of kinetic visual field testing, Goldmann's perimetry. We found that the visual field is larger in the two chronically deafferented subjects GL (Sarlegna et al. 2010) and IW (Miall and Cole 2007) compared to age-matched controls. More specifically, their detection of visual stimuli was enhanced in extreme peripheral vision (>70°) while performance was

similar in central vision and middle peripheral vision. This was found both in monocular and binocular conditions. The superior visual performance may reflect a functional correlate of plasticity of the somatosensory cortices and extend the view of cross-modal plasticity to subjects who suffered a late (age≥19) deafferentation.

P2.54 MULTISENSORY CORTICAL INTEGRATION IN PATIENTS WITH HEREDITARY CONE DYSTROPHY

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Hereditary cone dystrophies (HCD) are responsible of central visual impairment that determines deprivation of visual input in the portion of V1 corresponding to the macula. In macular diseases the “deafferented” portion of V1 can respond to other types of stimuli, (Baker CI et al.2005-2008; Masuda Y et al. 2008; Dilks DD et al. 2009). Cortical multisensory integration mechanisms have been reported in congenitally blind patients but it is still debated whether these processes occur in late blindness (Burton H and McLaren DG 2006; Voss P et al 2008; Gougoux F et al 2009; Klinge C et al 2010; Lewis JW et al 2011). We used fMRI and DTI (3T Philips Medical System scanner) to evaluate a) uni- versus hetero-modal recruitment of V1 and A1 in 10 normal subjects; b) audio-visual integration in the portion of V1 corresponding to the scotoma and quantify the integrity of optic radiations and connections between V1 and A1 in 10 HCD patients. The ON stimuli were expanding-contracting visual flow motion (extending 3 deg within the scotoma), auditory looming-receding flow motion, or a combination of the two. The OFF stimulus was a grey background with peripheral square stimulus to help fixation. BV QX 2.0 and DTI Studio 2.4.01 were used for fMRI and DTI analysis. DTI results revealed no differences in white matter microstructure between patients and controls. fMRI data suggested some form of cortical reorganization since sounds activated deafferented V1 in HCD (contrary to blind folded subjects) but only when not competing with visual information.

POSTER SESSION 3: BODY, ACTION AND TOUCH

P3.55 MEASURING VISUAL SELF-AGENCY

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Visual self-agency is the capability of acting causally in the world with the gaze, for example when interacting with gaze-operated devices. We developed a tool to assess the degree of awareness of this special sensori-motor contingency. In a first visual-acoustic task we asked whether naïf adult observers eventually discover visual self-agency. Fifteen observers watched a display consisting of several bouncing balls. Each time the observer made a saccade a beep was generated (mean delay: 67 ms). The task comprised 8 trials, each lasting 20 s, with a progressively decreasing number of balls. Observers had to understand the origin of the beeps. Despite observers had previously undergone a familiarization task in which beeps were generated when their gaze was directed to the right hemifield – thus becoming aware that their gaze may affect beeping, only 20% of them discovered the rule in the first trial, and reached 80% by the 6th trial, when one ball was displayed. In a subsequent task we probed the sensitivity to this sensory-motor contingency. Observers had to tell whether or not the beeps depended on their eye movements through a 2AFC task design (40 trials, duration 10 seconds). In half of the trials beeps were generated independently of saccades, and the contingency strength between beeps and saccades onset was 0.4. The mean accuracy was 80% (d’=1.2). Thus, this tool can detect both augmented and decreased visual self-agency and the underlying oculomotor explorative activity, and may be useful to characterize self-awareness e.g. during development and in pathological populations.

P3.56 ACTION AS A UNIFIER OF PERCEPTUAL EXPERIENCE

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Conscious experience requires the integration of sensory information processed by different senses. The integration of sensory modalities strongly depends on whether these modalities are perceived simultaneously. However, processing time might strongly differ between senses. Thus, the brain must be able to adapt to these differences and recalibrate its perception of synchrony. We report a study investigating whether the ability to predict the specific auditory and visual outcomes that an action produces, promotes recalibration of our perception of audiovisual simultaneity. We show that auditory and visual components of an audiovisual outcome are perceived simultaneously when this outcome is predicted compared to when it is unexpected. This suggests that action control processes promote the integration of predicted auditory and visual outcomes into a single audiovisual event. Actions structure the perception of our environment, temporally binding multimodal features, to create a coherent representation of the external world.

P3.57 IRRELEVANT TACTILE STIMULATION BIASES VISUAL EXPLORATION

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We evaluated the effect of irrelevant tactile stimulation on humans' free-viewing behavior during the exploration of complex static scenes. Specifically, we address the questions of (1) whether task-irrelevant tactile stimulation presented to subjects' hands can guide visual selection during free viewing; (2) whether tactile stimulation can modulate visual exploratory biases independent of image content and task goals; and (3) in which reference frame these effects occur. Forty-seven right-handed subjects participated in a free viewing task while their eye movements were recorded, and tactile stimulation to uncrossed or crossed hands was provided at random moments of visual exploration. Tactile stimulation resulted in a long-lasting modulation of visual orienting responses. Subjects showed a well-known leftward bias during the early exploration of images, which was modulated by tactile stimulation presented at image onset. Both with uncrossed and crossed hands, tactile stimulation biased visual orienting globally toward the space ipsilateral to the stimulated hand, but did not elicit reactive saccades to the actual location of the stimulated hand. In conclusion, our results indicate that tactile-to-visual cross-modal cues produce spatially global and long-lasting orienting responses, which appear to be coded exclusively in external coordinates.

P3.58 TACTILE SUPPRESSION WHEN REACHING TO VISUAL AND PROPRIOCEPTIVE TARGETS

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The perception of tactile stimuli is suppressed during movement planning and execution. Previous studies found higher detection thresholds for tactile stimuli in single-joint and in complex reaching and grasping movements towards visual targets. Here, we examined whether the target modality influences tactile suppression during movement planning and execution in a reaching task, either towards a visual (LEDs) or proprioceptive target (thumb and index finger of the stationary hand). Participants had to discriminate the intensity of two supra-threshold vibrotactile stimuli (250 Hz, 50 ms) delivered simultaneously, either during movement planning or execution, to the dorsal surface of two digits: the little finger of the left stationary hand, which served as reference and always received one stimulus of constant intensity, and the index finger of the right moving hand, which received one stimulus of variable intensity. Participants responded by button press which of the two stimuli felt stronger. Discrimination performance was measured in three conditions: no-movement control, reaching to visual targets, and reaching to proprioceptive targets. We fitted the data to a psychometric function and calculated the PSE and the JND. As expected, movement planning and execution suppressed the intensity of the stimulus on the moving digit (shift in PSE). It also led to less precise discrimination performance (higher JND). The suppression was more pronounced for reaches to visual than proprioceptive targets. Our results suggest that tactile perception may be enhanced when tactile feedback of the reach goal is relevant.

P3.59 FEELING OF BODY OWNERSHIP CHANGES INTEROCEPTIVE ACCURACY

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Interoceptive and exteroceptive information are both essential for the construction and update of self-awareness. Whereas several studies have shown how interoceptive awareness or cardiac feedback influence body-ownership (Tsakiris et al., 2011; Suzuki et al., 2013; Aspell et al., 2013), no studies have looked at the reverse effect, namely how exteroceptively-driven changes in body-ownership can influence individuals' ability to detect internal bodily signals. We exposed participants to the Rubber Hand Illusion and tested how this updated sense of body-ownership affected their interoceptive accuracy (IA). We used heartbeat counting as a proxy of interoceptive accuracy. Participants performed the heartbeat counting task before the RHI to obtain a baseline measure. Then, the test heartbeat counting trials were interleaved with periods of visuo-tactile stimulation. Participants received 60 s of visuo-tactile stimulation – synchronous to the rubber hand in the RHI condition and asynchronous to the rubber hand in the control condition, followed by the heartbeat counting task. After each trial, participants verbally indicated the number of heartbeats they had counted. At the end of both the RHI and RHA conditions, participants were given to complete a questionnaire on their experiences of illusory ownership during multisensory stimulation. We found that the experience of RHI significantly improved performance of participants with low IA, but did not benefit participants with high IA. These results suggest that, in the process of disowning one's own body-part and owning a new one, individuals with low IA benefit from exteroceptive bodily signals in order to acquire information about their internal state.

P3.60 EFFECTOR MOVEMENT INFLUENCES THE REFERENCE FRAMES FOR PROPRIOCEPTIVE REACH TARGETS

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Previous studies suggest that the brain represents reach targets in multiple spatial reference frames. The contribution of each reference frame is flexibly adjusted to the current sensorimotor context. For example, we recently showed that an effector movement between encoding and reaching to a proprioceptive target induced- otherwise absent- gaze-dependent coding of its remembered location. The present experiment explores whether gaze-dependent coding after movement comes at the expense of gaze-independent coding or whether it is employed in addition to gaze-independent reference frames. Participants were asked to reach to an unseen finger of their left hand indicated by a mechanical touch (proprioceptive target). We dissociated body-, hand-, and gaze-centered reference frames by varying the location of the target relative to the body midline, the start location of the reaching hand, and gaze, respectively. Participants completed two conditions where the target hand remained either stationary at the target location (stationary condition) or was actively moved to the target location, received a touch and was moved back before reaching (moved condition). We performed regression and correlation analyses to estimate how each reference frame contribute to the reach errors in the stationary and moved condition. Gaze-centered coding was only present in the moved condition, replicating our previous results. Body-centered coding dominated in the stationary condition but showed a decreased influence in the moved condition. Body- and gaze-centered coding contributed equally in the moved condition, thus indicating a shift from mainly body-centered to combined body- and gaze-centered coding of proprioceptive reach targets due to effector movement.

P3.61 THE EFFECT OF DELAYED VISUAL FEEDBACK ON `ROBOT` HAND ILLUSION: A NEAR-INFRARED SPECTROSCOPY STUDY.

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Rubber hand illusion (RHI) is a subject's illusion of the self-ownership of a rubber hand that was touched synchronously with their own hand. While RHI is an illusion regarding visual and tactile integration and hence is about the sense of self-ownership, it is natural to consider a similar illusion regarding visual and motor integration. We may call this as "robot hand illusion" (RoHI), which is relevant to both the sense of self-ownership and the sense of self-agency. Our previuos study, showed that the subject felt significantly greater RoHI effects with visuomotor temporal discrepancies of less than 200ms both in the sense of self-ownership and the sense of self-agency but that weaker RoHI effect was still observed with temporal discrepancies of 300-500ms only in the sense of self-agency. Here we investigate the effect of RoHI with brain activity using near-infrared spectroscopy (NIRS). The result showed that a channel placed on the parietal region (angular gyrus) showed significant activation in the 100ms visual-feedback delay condition in the left hemisphere. ANOVA showed that there are significant difference between the 100ms condition and larger delay conditions (400ms, $p<0.05$; 700ms, $p<0.1$). These results demonstrate that the activity in the angular gyrus area was modulated by the delay between the motor command and visual feedback of the virtual hand movements. We suppose that the angular gyrus is essential for integrating motor and visual information to distinguish one's own body from others.

P3.62 GHOSTS EXPERIENCE INDUCED BY ROBOTIC SENSORIMOTOR CONFLICTS

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The feeling of a presence (FoP) is the strange sensation that somebody is nearby when no one is actually present and cannot be seen. Although this phenomenon has been reported by psychiatric and neurological patients and healthy individuals in extreme situations, its brain origin remains unknown. A recent study used lesion analysis and analysis of associated neurological deficits and showed that the FoP is caused by abnormal integration of proprioceptive, tactile and motor signals in three distinct brain areas, and it is linked to sensorimotor deficits (Blanke et al., 2014). Here we report the results of three behavioral studies using a master-slave robotic system able to generate sensorimotor conflicts and induce the FoP in healthy participants. The robot-controlled FoP was assessed through spontaneous reports (study 1), dedicated questionnaires quantifying subjective experience (study 2), and implicit behavioural measures quantifying the location in space where people experienced their center of awareness (i.e. self-location; study 2). The data ($N = 38$) show that the robotic system is able to induce the FoP experimentally in healthy subjects and that the FoP is associated with systematic changes in self-location. In study 3, these data were further corroborated by systematic changes in the number of people that the participants experienced to be present close to their body when the FoP was induced. Globally, our data show that the FoP is caused by misperceiving the source and identity of sensorimotor signals of one's own body, and advance experimental approaches for the understanding of schizophrenic delusions.

P3.63 DOES THE VESTIBULAR SYSTEM PLAY A ROLE IN PERCEIVED HAND POSITION?

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The vestibular system plays an important role in the perception of one's hands. Disruptive galvanic vestibular stimulation (GVS) promotes reach trajectory errors and increases susceptibility to hand and body ownership illusions (Bresciani et al., 2002; Lopez et al., 2010). How might GVS affect the perceived position of the hands? Participants sat with their index finger attached to a motorized bar hidden behind a viewing screen. Their finger was passively moved to one of five orientations between ± 10° of vertical. Participants indicated the orientation of their unseen finger by manipulating a visual probe (9 x 1.5 cm, viewing distance 30 cm) optically superimposed on their hand position. Disruptive GVS was applied before, during, or after movement or not at all, in an order randomized across participants. All participants were right handed and both hands were tested. Without GVS, the perceived orientation of the hands was biased inwards, towards the body midline, and the range of perceived hand orientation was compressed by about 35%. GVS biased perception of the left hand further in towards the midline independent of whether it was applied before, during or after the movement, but had no obvious effect on the right hand. The vestibular system may facilitate the representation of the hands in external space. When the representation is not as robust (such as for the non-dominant hand), disruption of vestibular input induces stronger biases of perceived hand orientation.

P3.64 BETWEEN SELF AND OTHER IN MOTOR CONTROL

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The sense of agency refers to the subjective experience of controlling one's own action that "I am causing my own action". This sense is sometimes regarded as a postdictive illusion of causality. When it comes to motor control, however, agency has an important function in theory. When we move our own body, we implicitly attribute that movement to ourselves and utilize that sensory information (e.g., visual feedback) in order to correct "our own" movement: which is feedback control. The current study examined this intrinsic relationship between self-other sensory attribution and feedback control in motor control. The current study, where the participants were asked to trace a sine wave target using a pen tablet device, examined the effect of "self or other" visual feedback on the subjective agency rating as well as on the motor performance. The result indicates that the subjective ratings and motor performance highly depend on the self-other morphing ratio of the visual feedback, suggesting the sense of agency as the coordinator within the sensorimotor dynamics.

P3.65 FACE SIZE PERCEPTION IN HEALTHY ADULTS DEPENDS ON ORIENTATION

D'Amour Sarah, Harris Laurence

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Perceptual body size distortions have traditionally been studied in clinical populations using subjective, qualitative measures. However, it is imperative to accurately determine baseline measures of how well healthy populations are able to judge their body size. Previous research has typically focused on measuring distortions of the entire body and has tended to overlook the face. Here, we present a novel psychophysical method for determining perceived body size that taps into their implicit body representation. Participants were sequentially shown two images of their face, viewed as in a mirror. In one image, the aspect ratio (either the horizontal or vertical dimension) was varied using an adaptive staircase, while the other was undistorted. Participants reported which image most closely matched their own face size. The algorithm homes in on a ratio 2x removed from the chosen image because 50% response rates occur both when the two images are the same, and when distorted and actual images are equally far from the size regarded as correct. Participants were tested with face upright, tilted 90° left or right, or upside down. The Body Shape Questionnaire (Cooper et al., 1986) was also administered. We found a significant distortion in perceived face width (but not length) in which the face was judged as too wide, but only when viewed upside down. These results provide the first psychophysically robust measurements of how accurately healthy participants perceive the size of their face, revealing a special relationship between the face and the self.

P3.66 INVESTIGATING SELF VS. OTHER BODY PERCEPTION WITH THE BODY-SPECIFIC N190 COMPONENT.

Groves Katie, Kennett Steffan, Gillmeister Helge

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There is increasing evidence that suggests, similarly to faces, the human body is processed distinctively in the brain. Event related potential studies show that the visual observation of human bodies elicits an enhanced N190 component over occipital-parietal electrodes with the source being localised to the Extrastriate Body Area (EBA). However, to our knowledge, research to date has not investigated whether the N190 is sensitive to the self. Therefore, the aim of this study was to investigate electrophysiological body perception with regards to the self vs. other. We also aimed to explore whether the graded response seen in the EBA to bodies, body parts and other stimuli would be reflected in the N190. Electroencephalography (EEG) was used to assess the magnitude of the body-specific N190 component and the 'Body Consciousness Questionnaire' was used to assess bodily focus. Reaction times and accuracy

were monitored as participants were tasked with discriminating between standardized images of their own and other bodies, their own and other body parts as well as houses and house parts. N190 amplitudes were correlated with behavioural measures and findings indicate a heightened response to the self vs. other over the right hemisphere. A graded response was also evident in the N190 with the largest amplitudes elicited to bodies and body parts in comparison to houses and house parts. Such findings provide further evidence of a specialized neural system for the visual perception of human bodies whilst indicating that not only is the N190 sensitive to form, but also to identity.

P3.67 DOES GAZE POSITION ATTRACT OR SHIFT TOUCH LOCALIZATION? DATA FROM THREE RESPONSE METHODS

Pritchett Lisa M, Harris Laurence R

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We have previously shown that perceived location of touch on the torso is affected by gaze position. We put forward a model that could explain why touch localization is shifted in opposite directions by gaze depending on whether touch is coded relative to the orientation of gaze or of the body (Pritchett et al., Exp Brain Res 2012, 222:437-45). Such models predict that all touches coded in one reference frame would shift by an amount proportional to gaze eccentricity. Here, an alternative model is considered where gaze position acts as an attractor for the perceived position of a touch. Nine participants reported the perceived locations of eight vibrotactile stimuli arranged across the front of the torso. Vibrations were delivered while gaze was directed at one of seven locations between ±45°. Before reporting perceived location, participants returned their gaze to center. Three response methods were used: a visual method (reporting the location on a line), a numerical method (reporting a number for the part of skin stimulated), and a motor method (pointing to the perceived location). The effect of gaze on perceived touch location depended on the response method used, the distance between gaze and touch location, and the location of the touch on the body. These results test predictions of our previous model and will have implications for our understanding of the reference frames and mechanisms used for coding touch location.

P3.68 VISUAL FIRST-PERSON PERSPECTIVE EMBEDDED IN THE KNEE ALTERS THE PERCEPTION OF CUTANEOUS PATTERNS

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In the perception of cutaneous patterns, it is known that a cutaneous pattern is perceived as right-left reversed or not, depending on the position of the body surfaces where a cutaneous pattern is presented (Parsons & Shimojo, 1987). This phenomenon called ‘disembodied eye’ (Corcoran, 1977) has been explained by the concept of egocentric aspect of our visuo-spatial recognition that depends on where we see our body surfaces through the perspective directed forward. The explanation provides the possibility that the position of our visual perspective influences the tactile perception of our body surfaces. Here we examined whether the cutaneous-patterns perception changed when the visual perspective was embedded in other position of the body (e.g., visual perspective on the knee) using virtual reality technology. In the experiment participants wore a head-mounted display (HMD) connected to the video camera put on their knee, and were asked to report the tactile perception of letters (b, d, p, and q) drawn on their forehead and knee in pre and post adoption of altered perspective. The results indicate that the response of cutaneous-patterns perception after adoption of altered perspective differed from the response before adoption. The rate of change in cutaneous-patterns perception was higher than that of control group adopted normal position of visual perspective through HMD. This finding demonstrated that the position of visual first-person perspective altered the perception of cutaneous patterns on our body surface.

P3.69 MULTISENSORY COUPLING IN TOOL-USE

Debats Nienke, Heuer Herbert, Ernst Marc

Cognitive Neuroscience & CITEC, Bielefeld University ~ Bielefeld ~ Germany

Fusion of multiple redundant sensory inputs occurs when the sensory inputs are spatially or temporally correlated, such as when they originate from the same object or event. Interestingly, these conditions are only partially met in tool-use, where typically the seen effective part of the tool is spatially separate, yet highly correlated with, the felt acted-on part of the tool. We here examined whether one can describe bimodal interactions in tool-use with a Bayesian model that includes a coupling prior to capture the degree of relatedness between the signals. Participants directed the motion of a cursor on a monitor using a stylus on a tablet (i.e., the ‘tool’ merely is the spatial transformation rather than a physical one). During the goal-directed movements the motion of the cursor was rotated with respect to the motion of the hand. Participants judged the goal position of either their hand or the cursor. As expected, we found that the estimates of hand position were biased towards the cursor position, and vice versa. The sum of the biases was less then 100%, indicating that the position estimates were indeed coupled rather than fused. The strength of the biases was adequately predicted from the relative reliabilities of uni-modal judgments of hand and cursor position (i.e., baseline conditions). The variances of the biased estimates, however, were higher than predicted, suggesting that additional noise sources are involved.

P3.70 REACHING IS BELIEVING: THE ROLE OF LIMB-TARGET REGULATIONS PROCESSES IN AUDIOVISUAL PERCEPTION DURING ACTION.

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Perceptual processes are altered as one engages in goal-directed actions. For example, when presented with an audiovisual illusion (Shams et al., 2000; Andersen et al., 2004) during upper-limb reaches, individuals are more accurate at perceiving the number of visual events at the high vs. the low velocity portions of the trajectory (Tremblay and Nguyen, 2010). In the present study, we examined if limb-target regulation processes (i.e., adjustments of the limb trajectory based on the position of the limb vs. the target: Elliott et al., 2010) could explain this change in perception. Fifteen participants performed rapid upper-limb reaching movements to a 30 cm visual target in two room lighting conditions (i.e., vision vs. no-vision of the limb and environment). Below the foveated target, audiovisual stimuli were presented in a control condition (i.e., rest) and at 0, 100, and 200 ms relative to movement onset. The control condition data confirmed the presence of the illusion at rest. Also, similar to previous observations, participants were more accurate in their perception of the number of visual events when the illusion was presented at high vs. low limb velocities. Interestingly, there were no significant changes in the perception of visual events when the room lights were off and analysis of endpoint errors and movement trajectories revealed that these no-vision trials were significantly less affected by online limb-target regulation (Elliott et al., 2010). Overall, these results support the hypothesis that engagement in limb-target regulation processes improves the processing of visual vs. auditory events during goal-directed actions.

P3.71 THE EFFECTS OF MULTISENSORY CUES ON THE SENSE OF PRESENCE AND ON THE HUMAN TASK PERFORMANCE IN VIRTUAL REALITY ENVIRONMENT.

Cooper Natalia

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The aim of this study was to evaluate the effect of visual, haptic and audio sensory cues on participant's sense of presence and task performance in virtual environment. Participants were required to change a wheel of a (virtual) racing car in the 3D environment. Subjective ratings of presence and comfort were recorded. The time taken to complete the task was used as an objective measure. Auditory, haptic and visual cues signalling critical events in the simulation were manipulated in a factorial design. Participants wore 3D glasses for visual cues, headphones for audio feedback and vibration gloves for tactile feedback. Events, such as the full extraction of a bolt were signalled by haptic, acoustic and visual cues or combinations of cues. Data was collected in two blocks containing all eight sensory cue combinations: the task was once performed in a normal VR environment (control) and once (motion) in an environment where the position of the virtual environment was sinusoidally modulated by 2 cm in the depth plane at 0.5 Hz to simulate inaccurate participant tracking. All participants completed all 16 conditions in a pseudorandom sequence to control for order and learning effects. Subjective ratings for presence, discomfort and perceived cues effectiveness were recorded after each condition. Participants performed best when all cues were present. Significant main effects of tactile cue presentation on task performance and also on participants' presence ratings were found. We also found a significant negative effect of environment motion on task performance and participants' discomfort ratings.

P3.72 MULTISENSORY MANIPULATION OF BODILY SELF-CONSCIOUSNESS AFFECTS HIGH-LEVEL PROCESSING.

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Embodied cognition theories suggest the importance of the body for cognition, by posing that so-called high-level cognitive processes depend on the experience of the body. The concept of bodily self-consciousness (BSC) encompasses the experience of owning and the experience of being within a body at a given location. BSC can be altered by providing conflicting multisensory input (Full Body Illusion, FBI), inducing ownership for an avatar. Here we test the hypothesis that altering BSC by means of the FBI would impact high-level processing. We combined the FBI with an implicit association task. Participants were presented with a landscape image where words, conveying semantic contrasts in terms of spatial ("Near", "Far") or social ("Us", "Them") distance appeared superimposed in the landscape either in a proximal or a distal position. Words' "semantic" distance can be congruent or incongruent to words' spatial position. Participants were asked to classify words' spatial position. This task was intermingled with sessions of visuo-tactile FBI stimulation, during which participants were touched on their back, while viewing an avatar - presented in the distal position - being touched, either synchronously to induce the FBI, or asynchronously. In the asynchronous condition participants responded faster when the words' implicit semantic distance matched their spatial position. However, during the FBI when subjects self-identified with the avatar at the distal position, the facilitation effect of the words' spatial-semantic congruency disappeared. These results demonstrate that conceptual processing is not referenced to the physical body location, but to the experienced location of the participant's self.

P3.73 LATERALITY AND BODY OWNERSHIP: EFFECT OF HANDEDNESS ON EXPERIENCE OF THE RUBBER HAND ILLUSION

Smit Miranda, van der Ham Ineke, Kooistra Dagmar, Dijkerman Chris

University of Utrecht ~ Utrecht ~ Netherlands

Sense of ownership relies on multisensory integration and is thought to be right lateralized. Several studies suggest that mixed handed individuals have greater interhemispheric connectivity and consequential accessibility to the right hemisphere than extreme handed individuals (Christman et al. 2008; Prichard et al. 2013). Previous results indeed suggest that mixed handed participants are more susceptible for a subjective sense of ownership than extreme handed participants. We therefore assume that due to greater interhemispheric connectivity mixed handed participants have a greater experience of the RHI than extreme handed participants, which was mostly evident in the left hand. Sixty-three participants were included and were a priori allocated in either the group of sinistrals, mixed handed or dextrals. Stroking was synchronously and asynchronously performed on both the left and right hand of the participant and a left or right rubber hand. Outcome measures were embodiment questionnaire and proprioceptive drift. Results show that experience of the RHI was similar (synchronous > asynchronous) for both sinistrals, mixed handed participants and dextrals. In addition, experience of the RHI is similar for the left hand and right hand in all participants. Visuotactile integration is thus not influenced by handedness. In addition, plasticity of body ownership and embodiment are similar for the left and right hand in a healthy population. These results suggest a similar and equal sense of ownership, and a multisensory representation for both hands in the brain, what might be functional in order to keep a coherent sense of the body in space.

P3.74 EXAMINING SPATIAL AND MOTOR CONGRUENCE IN A MIRROR BOX ILLUSION

Liu Yuqi, Medina Jared

University of Delaware ~ Newark ~ United States

In the mirror box illusion, individuals report greater limb ownership when the movements of the unseen hand behind the mirror and the viewed mirror reflection are synchronous versus asynchronous. When synchronous, movements are yoked both spatially (movement direction in external space) and motorically (movement direction in a hand-centered reference frame). To examine the contributions of spatial and motor congruence in multisensory integration, we manipulated hand posture (palms up, palms down) and motor congruence (flexion or extension of the metacarpophalangeal joint of index finger) of the viewed and hidden left hand in a mirror box. We found significantly higher ownership ratings when movements were spatially congruent, providing evidence for a greater weighting of spatial information. To examine the influence of increased visuomotor information on limb ownership, we performed a second, similar experiment with full flexion/extension of four fingers. In contrast to the first experiment, we found a significant effect of motor congruency on ownership ratings, with no effect of spatial congruence. Even when movements were spatially incongruent (but motorically congruent), participants reported a strong sense of visual capture such that they felt their hand moving in the direction of the viewed movement. These results suggest that increased visuomotor information leads to stronger weighting of motor versus spatial information in visual-proprioceptive integration.

P3.75 VISUAL INTERFERENCE AND SUBTYPES OF MIRROR-TOUCH SYNESTHESIA

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A subset of the population experiences touch on their own body when observing someone else being touched - mirror-touch synesthesia. Past studies have provided evidence, based on self-report, for different subtypes of mirror-touch synesthesia. Somatotopic mirror-touch synesthetes map viewed touch to the same location on their own skin surface, whereas external mirror-touch synesthetes map viewed touch to the same side of space. We further examined the spatial specificity of these percepts using a tactile congruency task. Participants viewed videos of a left or right hand from different perspectives (1st or 3rd person) being touched (or not touched) on the index or ring finger. While watching the video, participants were presented with no stimulation or an automated tactile stimulus to either finger, and were asked to quickly respond (via foot pedals) to where they were touched. Mirror-touch synesthetes were significantly slower and made significantly more errors on this task compared to controls. Both mirror-touch synesthetes and controls demonstrated a spatial congruency effect – faster responses when the viewed and felt stimulus were on the same side of space. However, this effect was significantly greater in mirror-touch synesthetes versus controls. Finally, somatotopic mirror-touch synesthetes demonstrated a somatotopic congruency effect (faster responses when the video and actual stimulus were on the same fingers), whereas external mirror-touch synesthetes demonstrated a spatial congruency effect (faster responses when the video and actual stimulus were on the same of space). These results provide evidence for different spatial representations influencing the perceived location of mirror-touch synesthetic percepts.

P3.76 TO SUP WITH A LARGE SPOON: AN ILLUSION OF VISCOSITY WITH A TOOL

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In this research, we asked how the shape of a spoon can influence perceived viscosity of a liquid and whether using visual and haptic cues can aid in discriminating viscosity. We asked participants to compare the viscosity of two liquids stirred using the same or a different spoon: One spoon had a large circular spatula of 5cm diameter and the other had a small spatula of 3 cm diameter. Participants could either: a) stir the liquid while they had full view of the inside of the container, or b) stir the liquid but could not see it because the container was opaque and placed above the line of sight, or c) a confederate stirred the liquid and participants could only passively observe the stirred liquid. Viscosity discrimination using the same spoon was found to be best in the passive vision-only condition, and worse in the haptic-only condition. Intermediate performance was found for the visual-haptic condition. Changing spoon leads to an interesting set of results: stirring the same liquid using a large spoon makes it feel thicker than stirring it using a small spoon (irregardless of whether vision was allowed or not). This effect is greatly reduced if the stirring is passively observed. Summarizing, to better judge the viscosity of a stirred liquid it is better not rely on haptic cues alone. To avoid biases in the comparison of two liquids, moreover, one should use the same spoon to stir both.

P3.77 CUE-DEPENDENT EFFECT OF ACTIVE HAND MOVEMENT ON VISUALLY PERCEIVED DEPTH.

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In the present study, the contribution of active hand movement on perception of movement in depth was investigated. A previous study (Umemura, PLoS ONE, 2014) reported that visually perceived movement in depth was affected by synchronizing hand movements which were passively given. In the experiments, participants actively moved their hand toward near or far, and the surface shape which was given by binocular disparity was synchronously changed. Different from the previous study, the hand movement did not affect the visually perceived depth movement. It was speculated that because the participants could predict the correct depth change produced by their active movement, the difference between hand movement and visual stimulus was detected and information from two modalities was not combined. In Experiment 2, visual stimuli defined by shading were used. It was expected that the depth change defined by shading could be affected by active hand movement because they do not involve information about absolute distance which should be used for the comparison between visual and haptic depth changes. The results showed that the perceived change in depth was shifted toward the depth direction indicated by the hand movement.

P3.78 THE EFFECT OF HAND POSITION ON TACTILE SPATIAL PERCEPTION

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We investigated the effects of different kinds of visual spatial alignment of hand posture on tactile spatial perception. Specifically, we examined whether 'hand-centred' and 'eye-centred' reference frames affect tactile spatial acuity using dummy hands and the grating orientation task (GOT). Transcranial Magnetic Stimulation (TMS) was used to examine the role of primary somatosensory cortex (S1) and peripheral nerves of the hands on tactile discrimination threshold. Healthy adult participants received brief touches to their fingertips of grated objects delivered by a computer-controlled robotic manipulator. Their task was to decide whether the gratings ran 'along' or 'across' their finger. The GOT provides a sensitive measurement of tactile spatial acuity. Between GOT trials, we used the QUEST psychophysical staircase procedure to measure the smallest grating width for which participants could reliably discriminate between different grating orientations. In different conditions, dummy hands were placed in visual alignment or misalignment with the participant's own hand. Moreover, the participants performed the GOT task while their S1 and median nerves were stimulated by TMS. Our poster reports the initial results of these experiments.

P3.79 MAPPING NOCICEPTIVE STIMULI USES LIMB-CENTERED PERIPERSONAL FRAMES OF REFERENCE.

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Coordinating the perception of the location of an object in external space with the perception of its impact on the body is important to adapt behavior, more crucially when the object becomes noxious, i.e. has the potential to inflict tissue damage. Here, we investigated

the impact of visual stimuli on the temporal order judgements of two nociceptive stimuli applied to either hands. More specifically, each pair of nociceptive stimuli were shortly preceded by a lateralized visual stimuli delivered at different positions according to the anteroposterior axis (i.e. in depth in front of the trunk; Experiment 1), the mediolateral axis (i.e. eccentric distance from the sagittal body midline; Experiment 2), or the longitudinal axis (i.e. elevation; Experiment 3). The positions of the hands were also changed across blocks of stimulation (excepting in Experiment 3, the hands remained at the lowest position). Results showed that participant's judgements were mostly biased in favor of the nociceptive stimulus applied to hand the closest to visual stimulus, irrespective of the position of the hand in external space and the distance of the visual stimulus from the trunk. This suggests that spatial perception of nociceptive inputs uses spatiotopic reference frames that are centered on the stimulated body part.

P3.80 IS THE VESTIBULAR SYSTEM INVOLVED IN UPDATING THE PERCEIVED LOCATION OF TACTILE STIMULI?

El-zein Yasmeenah, Harris Laurence R

York University ~ Toronto ~ Canada

Emerging studies suggest that tactile stimuli are initially localized relative to the body but are converted to a gaze-based reference system if the location is to be updated in space during a change in position. The vestibular system provides a reference for the representation of the body in space and therefore might be involved in converting touch location into a space-based reference system. To investigate this we used disruptive galvanic vestibular stimulation (dGVS) during tactile localization tasks chosen to encourage body- or gaze-based coding. Participants looked 90° left or right, or straight ahead during a touch from one of eight vibrotactile tactors equally spaced across the front of the waist. They indicated the perceived location using a visual scale. In the static task, participants remained stationary between touch and reporting. In the dynamic task, participants returned to looking straight ahead before responding, thus requiring updating of the perceived location. Each task was performed with and without dGVS presented between the touch and any movement. The results confirmed previous findings showing gaze-related shifts predominantly towards gaze during the dynamic task and away from gaze during the static task, compatible with different coding systems being employed. dGVS affected judgements only during the dynamic task, reducing gaze-related shifts. We conclude that the vestibular system may play a critical role in updating the perceived location of touch when it is necessary to remember its location during a gaze change.

P3.81 VISUO-HAPTIC SLANT MATCHING IN FRONT AND REAR PERIPERSONAL SPACE

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Humans are constantly integrating visual and haptic spatial representations for successfully interacting with objects in peripersonal space. Previous researches have shown that both visual and haptic perception of orientation are susceptible to systematic egocentric bias in frontal peripersonal space. Since rear peripersonal space is out of the visual field, it is not clear how haptic information in rear space is transformed and integrated into visual representation, and vice versa. In this study, we investigated the error patterns in visuo-haptic slant matching tasks where the participants manipulated a test board with both hands to set it parallel to a reference board in the three dimensional space. The reference board was presented visually at eye level. The hand position was set at different front and rear locations in the midsaggital plane. Our data show that at the locations above eye level, the slant of the test board was exaggerated, while at the location below eye level, the slant was set shallower than the reference board. The deviations in rear space were significantly larger than those in front space, but still in the same direction. The results suggest that an egocentric bias may also exist in rear space and the difference of deviations between rear and frontal conditions reflects a further distorted visuo-proprioceptive transformation in rear peripersonal space.

POSTER SESSION 4: PLASTICITY, LEARNING AND RECALIBRATION

P4.82 CROSS-MODAL TEMPORAL STATISTICAL LEARNING RECALIBRATES PERCEPTION OF VISUAL APPARENT MOTION

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We examined whether the sensitivity of perceiving visual Ternus motion could be recalibrated through fast cross-modal temporal statistical learning. We launched three sessions of tests: pre-Test, learning and post-Test. In both pre-Test and post-Test, participants classified the types of Ternus motion ('element motion' vs. 'group motion'). In the temporal statistical learning session, they compared auditory and visual intervals. In visual-'inside' condition, two consecutively presented black dots (at the center of the screen, with inter-stimulus interval of 50-230 ms) were dominantly (80 %) flanked by two sound beeps. On the contrary, for auditory-'inside' condition, two sound beeps were dominantly (80 %) enclosed by two consecutively presented red dots. Participants were required to respond which interval (auditory vs.visual) was longer. In post-Test, the just noticeable differences (JNDs) for Ternus display with black discs were increased (i.e., reduced sensitivities) while the JNDs for Ternus display with red dics were reduced (i.e., enhanced sensitivities),

although the JNDs for both conditions of black-disc and red-disc were comparable in the pre-Test. Therefore, temporal statistical learning could quickly and selectively recalibrate the sensitivity of perceiving visual motion, dependent upon the temporal learning protocols.

P4.83 PREDICTIVE CODING OF VISUAL-AUDITORY AND MOTOR-AUDITORY EVENTS: AN ELECTROPHYSIOLOGICAL STUDY

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Tilburg University ~ Tilburg ~ Netherlands

The amplitude of auditory components of the event-related potential (ERP) is attenuated when sounds are self-generated compared to externally generated sounds. This effect has been ascribed to internal forward modals predicting the sensory consequences of one's own motor actions. Auditory potentials are also attenuated when a sound is accompanied by a video of anticipatory visual motion that reliably predicts the sound. Here, we investigated whether the neural underpinnings of prediction of upcoming auditory stimuli are similar for motor-auditory (MA) and visual-auditory (VA) events using a stimulus omission paradigm. In the MA condition, a finger tap triggered the sound of a handclap whereas in the VA condition the same sound was accompanied by a video showing the handclap. In both conditions, the auditory stimulus was omitted in either 50% or 12% of the trials. These auditory omissions induced early and mid-latency ERP components (oN1 and oN2, presumably reflecting prediction and prediction error), and subsequent higher-order error evaluation processes. The oN1 and oN2 of MA and VA were alike in amplitude, topography, and neural sources despite that the origin of the prediction stems from different brain areas (motor versus visual cortex). This suggests that MA and VA predictions activate a sensory template of the sound in auditory cortex.

P4.84 AUDIOVISUAL CONGRUENCY INCREASES EXPLICIT LEARNING IN A SERIAL REACTION TIME TASK.

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Even in the absence of any explicit awareness of its presence, humans can learn a repeating sequential pattern. This is frequently studied using a serial reaction time task; participants are visually cued to press one of several buttons as quickly as possible in a sequence that, despite appearing random, actually contains a repeating pattern. One commonly-used measure of learning for this task involves calculating the difference between reaction times of repeated and random sequences. However, whether this common measure is primarily representative of explicit or implicit learning, or some combination of the two, is not well established. In the current experiment, we examined how the addition of informative or non-informative auditory tones, temporally coincident with the visual cue, influenced various measures of learning. The commonly-used reaction time measure found no significant differences between tone conditions, yet a different measure specifically designed to estimate explicit learning found that informative tones resulted in more explicit learning than non-informative tones. These data suggest that while informative auditory tones enhance explicit learning, this enhancement does little to affect the commonly-used reaction time measure of sequence learning. This supports a complex and nonlinear relationship between explicit learning and traditional measures of sequence learning.

P4.85 VISUOMOTOR TEMPORAL RECALIBRATION LEADS TO SENSE OF AGENCY BUT NOT TO BODY-OWNERSHIP

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Bodily self-consciousness consists of the sense of agency (I am causing an action) and body-ownership (my body belongs to me). Both stem from the temporal congruence between different modalities, although some visuomotor temporal incongruence is acceptable for agency. To examine the association or dissociation between agency and body-ownership using their different temporal sensitivities, we applied a temporal recalibration paradigm, in which subjective synchrony between asynchronous hand action and its visual feedback can be perceived after exposure to asynchronous visuomotor stimulation (Keetels & Vroomen, 2012). In the experiment, participants continuously clasped and unclasped their hand while watching an online video of their hand with delays of 50, 110, 170, 230, 290, and 350 ms. Then, they rated a hand video without delay (test stimulus) with respect to the synchrony between hand action and video and the agency over the video. Moreover, proprioceptive drift of hand location toward the hand video during the exposure was measured as index of illusory body-ownership. Results indicated that agency emerged over the delayed hand video as subjective visuomotor synchrony was recalibrated, while body-ownership did not emerge for the delayed video even after the recalibration. We suggest a dissociation between agency and body-ownership following visuomotor temporal recalibration.

P4.86 TEMPORAL RECALIBRATION OF AUDITORY-MOTOR SIMULTANEITY AFTER IMITATION OF OTHER'S MOVEMENT.

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As seen in training of sports and dancing, people often move own body while observing and imitating other's movement. The observation of temporal lag between other people's movement and auditory feedback recalibrated subjective simultaneous points (PSSs) of own movement and auditory stimuli (Watanabe et al. 2011). However, the effect of the imitation of others including self-movement on the recalibration is still unclear. The aim of this paper was to investigate whether lag adaptation occurs after real-time imitation of other's movement followed by auditory stimuli with the lag. We hypothesized that the effect of lag adaptation is larger under the real-time imitation of other people's movement than under observation, due to gain feedback information of own movement. Our experiment was consisted of the adaptation and the test phase. In the adaptation phase, participants (N = 7) were exposed to time lags under three conditions: lags from self-movement (self-movement condition), other's movement without imitation of the movement (observation condition) or other's movement with the imitation (imitation condition) to auditory stimuli. The lag length was 50 or 150msec. In test phase, using temporal order judgment task in which people judged which auditory or tactile stimuli came first, we observed lag adaptations on the PSSs. By ANOVA, there were significant differences between both the adaptation conditions and the lag length conditions ($p < 0.05$ and $p < 0.01$ respectively). In addition, the imitation condition had a tendency to increase the effect of lag adaptation more than the observation condition.

P4.87 RAPID FUNCTIONAL AND STRUCTURAL CEREBRAL CHANGES IN RESPONSE TO MULTI-SENSORY, MUSICAL TRAINING.

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Musical training and language draw on cortical circuits that overlap significantly. We have previously shown that participants with prior music training show significantly correlated cerebral blood-flow velocity (CBFV) patterns when synthesizing music and producing language. Without prior training this correlation is absent (Meyer et al., doi:10.3389/fpsyg.2014.00552). The timescale of this remodelling is not known. We measured the correlation of CBFV patterns before and after training participants on a novel music task, polyrhythm drumming. After only one hour of training on this novel task, initially uncorrelated CBFV patterns changed in lateralisation and were correlated with those seen during cued word generation. We replicated this experiment with an fMRI study, extending a previous study (Meyer et al., doi:10.1162/jocn.2010.21593). Learning to drum the polyrhythms for one hour, followed by consolidation over night, causes significant change in inferior frontal brain activation patterns. While the fTCD and fMRI changes may well be explained as short-term, functional changes, we also performed a Diffusion Kurtosis Imaging scan to measure diffusivity in the brain to test whether rapid, learning-related, mean diffusivity reductions, which were first reported by Sagi et al. (doi: 10.1016/j.neuron.2012.01.025) in the hippocampus can be demonstrated. We show consistent MD reductions in hippocampus but not in a control region (Putamen). This is consistent with rapid structural changes to cortical structures during learning.

P4.88 ELECTROPHYSIOLOGICAL CORRELATES OF THE EFFECTS INDUCED BY AN AUDIO-VISUAL TRAINING ON HEALTHY PARTICIPANTS

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A wide range of evidence suggest that audio-visual stimuli presented in spatial coincidence enhance the activity of the subcortical collicular pathway. Here we tested the prediction that a spatially coincident audio-visual training might induce long lasting attentional and sensory ERP enhancements in healthy participants. EEG data were recorded before and after a two hours audio-visual training, during the execution of two lateralized visual tasks, differentiating each other for a more extensive involvement of the dorsal MT (Motion Task) or the ventral extrastriate (Orientation Task) pathway. During the training, participants were asked to foveate and detect audio-visual stimuli that were disproportionally allocated to one hemifield (trained hemifield). Half of the participants underwent a training in which audio-visual stimuli were presented in spatial coincidence, while the remaining half underwent a training where audio-visual stimuli were presented with a considerable spatial disparity (32°). Participants receiving the audio-visual coincident training revealed a post-training enhancement of the anterior N1 component in the Motion Task, in response to stimuli presented in the trained hemifield compared to the untrained one. However, they showed no effect in the Orientation Task. In contrast, participants receiving the audio-visual disparate training showed no effects in both tasks. The observed N1 effect might reflect enhanced attentional and sensory mechanisms, due to the increased activity of the retino-colliculus-dorsal MT pathway (subserving the Motion Task) induced by the audio-visual coincident training.

P4.89 MIND THE GAP! DISTANCE AFTEREFFECT IN PASSIVE TOUCH

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In vision, after prolonged observation of a stripped pattern, a grid of the same orientation with narrower bars is perceived even thinner. Although the existence of haptic size aftereffects is well-established, similar aftereffects with passive touch have not yet been reported. Here, we present a strong aftereffect of tactile distance induced by the simultaneous presentation of pairs of pointed tactile stimuli. Experiment 1 tested size aftereffects in a comparison paradigm analogous to that used for haptic experiments. During the adaptation phase, participants were touched sequentially along the mediolateral axis of each hand, with a larger stimulus on one hand, relative to the other. After adaptation, two stimuli of varying distances were presented. Stimuli delivered on the hand adapted to the smaller distance were perceived as bigger than stimuli on the opposite hand. Experiment 2, showed that relative distance comparison is not necessary for the aftereffect as adaptation to a specific length on one hand is sufficient: when the test stimulus was smaller than the one used for adaptation, the size of the stimulus was perceived even smaller. Experiment 3 showed that the aftereffect is orientation-specific and does not transfer to test stimuli rotated 90° from the adapting stimuli. The orientation specificity of the aftereffect along with the similar pattern of results observed in vision suggests a common phenomenon related to adaptation of size-selective neurons. More generally, these results show that tactile size aftereffects are not specific to haptics, but occur also in passive touch.

P4.90 THE MOTOR-VISUAL TEMPORAL RECALIBRATION DEPENDS UPON AWARENESS OF TEMPORAL LAGS

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Repeated exposure to a consistent temporal lag between voluntary actions and visual feedbacks induces recalibration of motor-visual temporal perception, and consequently shifts the point of subjective simultaneity (PSS) in subsequent temporal order judgments between the action and visual stimulus. In this study, we tried to understand the mechanism which underlies the motor-visual temporal recalibration by examining whether the recalibration was induced without awareness of the adaptive temporal lags. In Experiment 1, we allocated observers either the multiple-step or single-step lag conditions. In the multiple-step lag condition, we first introduced slight temporal lags and gradually increased the temporal lags during adaptation, in order to make observers unaware of the temporal lags. In the single-step lag condition, we introduced substantial temporal lags throughout adaptation, and instructed them about the introduction of the temporal lags before the adaptation, in order to make them aware of the lags. We found significant PSS shift only in the single-step lag condition. In Experiment 2, we had no instruction about the introduction of temporal lags in the single-step lag condition, and asked observers at the end of the experiment whether they were aware of the lag. We found no significant PSS shift for the observers who were unaware of the lag. These results suggest that awareness of the temporal lags play a critical role in the motor-visual temporal recalibration, and that the motor-visual temporal recalibration depends upon the cognitive processing which is involved in detection of a temporal lag between an action and a visual feedback.

P4.91 ASYMMETRICAL CROSS-TALK BETWEEN A MOTOR-VISUAL AND A MOTOR-AUDITORY TEMPORAL RECALIBRATION

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Perception of synchrony between one's own action (e.g., a finger tap) and the sensory feedback thereof (e.g., a flash or click) can be recalibrated after exposure to an induced delay (temporal recalibration effect: TRE). It remains elusive, though, whether the same mechanism underlies motor-visual (MV) and motor-auditory (MA) TRE. We examined this by measuring cross-talk between MV- and MA-delayed feedback. During an exposure phase, participants pressed a mouse at a constant pace while receiving visual or auditory feedback that was either delayed (+150 ms) or subjectively synchronous (+50 ms). During a post-test, participants then tried to tap their finger in sync with visual or auditory pacers. TRE manifested itself as a compensatory shift in the tap-pacer asynchrony (larger anticipation error after exposure to delayed feedback). In Experiment 1, MA- and MV-feedback were either both synchronous (MV-sync & MA-sync) or both delayed (MV-delay & MA-delay), whereas in Experiment 2 delays were mixed (MV-sync & MA-delay or MV-delay & MA-sync). Exposure to consistent delays induced equally-large TREs for auditory and visual pacers with similar build-up courses. However, with mixed delays, we found that synchronized sounds erased MV-TRE, but synchronized flashes did not erase MA-TRE. This suggests that a similar mechanism underlies MA- and MV-TRE (possibly a shift in motor-timing), but that auditory feedback is more potent than visual feedback to erase TRE.

P4.92 TRANSFER OF TACTILE PERCEPTUAL LEARNING TO UNTRAINED NEIGHBOURING FINGERS REFLECTS NATURAL USE RELATIONSHIPS

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Improvements in tactile perception, resulting from sensory training, are known to transfer from trained to naïve fingers. The pattern of transfer has been suggested to reflect the organisation of the somatosensory cortex, such that improvements spread to untrained fingers with overlapping cortical representation to the trained finger (e.g. adjacent and homologous fingers). In the current study, we wished to investigate whether habitual tactile coactivation resulting from cooperative finger use in daily life shapes somatotopic finger representation and, subsequently, learning transfer. To this end, we trained the middle finger using an orientation discrimination paradigm and investigated the time course of perceptual learning transfer. Using multiple threshold tests dispersed in-between training sessions, we identified differences in learning transfer to two fingers of the same topographic relationship (i.e. both physically and cortically adjacent) but of differing use profiles with the trained middle finger. While the index finger echoed the improvement of the trained middle finger over time, the ring finger was delayed, with improvements in tactile acuity at a later stage of learning. This divergence in learning between the untrained fingers was not due to peripheral differences, as demonstrated using the untrained control hand in the trained group and an additional no-training control group. We therefore suggest the observed divergence reflects differences in finger overlap in the somatosensory cortex, which are likely driven by differential co-activation resulting from documented patterns of use between the fingers. Our results emphasise the role of action in shaping perception and the organisation of the somatosensory system.

P4.93 MULTISENSORY PRIMING: SERIAL EFFECTS IN SIMPLE REACTION TIMES TOWARDS AUDIOVISUAL ASYNCHRONIES

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In multisensory reaction time paradigms the modality-shifting effect (MSE) refers to the finding that simple reaction times to stimuli in one modality are quicker when the previous trial required a reaction to the same modality (e.g., Spence et al., 2001, Perception & Psychophysics, 330-336; Sutton et al., 1961, The American Journal of Psychology, 224-232). In a first experiment we show that this effect is not specific to shifts in modality, as a quicker reaction to the stimulus presented in the previous trial is also found in simple reaction times to auditory stimuli varying in frequency. In a second experiment we investigate whether priming over modalities may also capture temporal asynchronies between auditory and visual stimulation. We find serial reaction time effects when asking participants to perform a simple reaction time task with audiovisual pairs in that reaction times decrease the lower the difference in asynchrony in the given and the previous presentation. This speaks for the MSE to be based on similar mechanisms as unimodal priming effects and demonstrates that these mechanisms can act on temporal characteristics of stimuli even between modalities.

P4.94 STATISTICAL LEARNED HELPLESSNESS IN HUMANS

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Statistical learning refers to the ability of human learners to capture regularities that occur over space or time. Yet sensory input often consists of many structured features (i.e., features that appear at high probability together), as well as random features. However, research to date largely explored statistical learning in a fully structured environment. Here we report a fundamental constraint on statistical learning: Randomness in the environment, even if unrelated to the learned material, dramatically impairs learning. In Experiment 1, participants in the structured condition were presented with fully structured visual input (reoccurring triplets of shapes). In the random condition the visual input was partly structured (triplets) and partly random (a set of random shapes). Lastly, in the multisensory random condition the input was multisensory, consisting of visual triplets and random syllables. Following familiarization, participants completed a familiarity test assessing knowledge of triplets. In the structured condition significant learning of triplets occurred. In contrast, in the random condition learning was completely extinguished. While modest learning occurred in the multisensory random condition, it was significantly less robust than in the structured condition. In Experiment 2 participants were presented with auditory input: Triplets of syllables in the structured condition, or triplets and random syllables in the random condition. Here, learning was unaffected by random input. This suggests that statistical learning proceeds differentially for visual and auditory input (or non-linguistic and linguistic) stimuli. These constraints on learning may have profound implications for the generalization of statistical learning to other learning domains.

P4.95 ADAPTATION TO HAPTIC SURFACE ORIENTATION: COMBINING INFORMATION ACROSS EXPLORATION MODES

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When haptically exploring objects, we can do this uni-manually or bi-manually. When exploring the objects uni-manually, we typically run one finger across the object and integrate the surface information across time (Serial Exploration). For bi-manual exploration, moving our hand is not necessary, since we can integrate the spatially distributed information across the static hands to get an estimate of e.g. the surface orientation (Parallel Exploration). Commonly, however, we use a combination of both exploration modes, e.g. using one hand as a static reference while the other hand is moving. Here we ask how information gathered in each of these modes interacts for generating a haptic percept.To investigate this we used an adaptation paradigm. We selectively adapted participants using one exploration mode (here static Parallel Exploration) and investigated whether adaptation transfers to unimanual Serial Exploration as well as to a condition in which both modes of exploration, serial and parallel, are used simultaneously (Mixed Condition). Using a task in which participants had to judge the orientation of a surface using different modes of exploration (Serial, Parallel, or Mixed) we found that adaptation for Parallel Exploration led to significant aftereffects when the same condition was used for testing. Furthermore, this aftereffect did not transfer to unimanual Serial Exploration, indicating that bimanual parallel information does not necessarily influence unimanual exploration. Importantly, in the Mixed Condition we found incomplete transfer of adaptation, suggesting that for bimanual exploration, perception depends on both serial information within a hand as well as bimanual parallel information.

POSTER SESSION 5: SPACE, TIME AND MOTION

P5.96 EVIDENCE FOR TIME DIVISION MULTIPLEXING OF MULTIPLE ITEMS IN AN AUDITORY CODING BOTTLENECK

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How the brain preserves information about multiple simultaneous items is poorly understood. We investigated whether neurons use time-division multiplexing, a telecommunications strategy for combining signals in a single channel. We evaluated single unit activity in a "bottleneck" of the auditory pathway, the inferior colliculus, IC, while monkeys reported the location(s) of one or two sounds presented simultaneously. We sought evidence that when two sounds are present, neuronal activity fluctuates in time between levels representing each sound, thus encoding both across time. The IC is a relevant test-bed for this question because it encodes location not through a map but through a meter; that is, firing rate rather than neural identity represents location. A firing rate code cannot encode multiple distinct items, except via time-division multiplexing. We tested how IC responses during dual sound localization trials compared to responses on the component single sound localization trials. For whole-trial spike counts, dual sound responses were often best fit by a mixture of single-sound Poisson distributions, indicating fluctuations across trials. Some responses showed within-trial fluctuations at a faster time scale (Hidden Markov Modeling). Overall, about half of conditions that could be tested in this analysis showed some form of fluctuating activity. The activity of simultaneously-recorded neurons positively correlated in time, suggesting that the population fluctuates together. In conclusion, when the scene contains two sounds, activity in the IC oscillates to retain information about both, suggesting a general mechanism that enhances capacity whenever neurons must code more than one thing at a time.

P5.97 EVOLUTION OF A REFERENCE FRAME ALONG A BRAIN PATHWAY: PERSISTENTLY HYBRID COORDINATES OF AUDITORY SIGNALS IN FRONTAL EYE FIELDS IMPLICATE THE SUPERIOR COLLICULUS IN COMPUTING EYE-CENTERED SOUND LOCATION

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Cues for determining visual and auditory locations differ. The retina provides information about the eye-centered location of visual stimuli, whereas sound location is inferred from cues that depend on the sound's position with respect to the head. The computations necessary to integrate these cues are a central problem in multisensory and sensorimotor integration. Are auditory signals transformed into an eye-centered frame for integration with vision? The only known pre-dominantly eye-centered auditory signals are found in the saccade-related bursts in the Superior Colliculus (SC), while all other known signals reflect hybrid head- and eye-centered information. We evaluated the reference frame of auditory signals in the Frontal Eye Field (FEF). The FEF is involved in saccade generation and projects to the SC. Thus the characterization of FEF's auditory code can resolve whether eye-centered sound location is broadly present in saccade-programming areas or emerges in the SC. We recorded from 324 FEF neurons while 2 monkeys performed delayed saccades to auditory targets from different initial positions. Similar to the SC, the initial sensory-related activity was encoded in hybrid head- and eye-centered coordinates. Unlike the SC, where such signals evolve in time to become eye-centered, the FEF's signals remained largely hybrid (roughly 60%) during the saccade-related burst. The proportion of eye-centered signals increased but remained a minority (13% during the sensory period vs. 30% during the saccade-related period). Overall, these results contrast considerably with those from the SC, and implicate the SC as the main player in the computation of eye-centered auditory target location.

P5.98 PASSIVE HORIZONTAL ROTATION AFFECTS SOUND LOCALIZATION ACUITY AT THE SUBJECTIVE FRONT

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Sound localization is regarded as a multisensory process including not only hearing, but also self-motion perception. Many studies have demonstrated that self-motion facilitates sound localization acuity, but few have shown that head rotation done only during sound localization degrades sound localization. This study used a spinning chair to examine listeners' sound localization acuity at the subjective front during passive rotation. A single 30-ms pinknoise burst (sound stimulus) was presented from a loudspeaker of a circular array (1.1 m radius) with a loudspeaker separation of 2.5 deg. The listener, sitting on the chair at the circle center, was asked to report whether the sound stimulus was presented from the left or right of the subjective front (2AFC) in chair-still and chair-rotation conditions. In the chair-still condition, listeners were asked to keep the head still but had no fixing jig. In the chair-rotation condition, listeners were rotated using the spinning chair. Results showed that localization acuity in terms of the detection thresholds of the subjective front of passive rotation condition were higher (worse) than that of chair-still condition. Furthermore, no significant difference of sound localization acuity at the subjective front was found irrespective of the spinning chair's rotation speed (5–20 deg/s). This tendency is the same as that found in our previous study, which examined the detection thresholds of sound localization acuity at the subjective front during active head rotation.

P5.99 SENSORIMOTOR SYNCHRONIZATION WHEN WALKING SIDE BY SIDE WITH A POINT LIGHT WALKER

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Synchronization of periodic movements like side-by-side walking [7] is frequently modeled by coupled oscillators [5] and the coupling strength is defined quantitatively [3]. In contrast, in most studies on sensorimotor synchronization (SMS), simple movements like finger taps are synchronized with simple stimuli like metronomes [4]. While the latter paradigm simplifies matters and allows for the assessment of the relative weights of sensory modalities through systematic variation of the stimuli [1], it might lack ecological validity. Conversely, using more complex movements and stimuli might complicate the specification of mechanisms underlying coupling. We merged the positive aspects of both approaches to study the contribution of auditory and visual information on synchronization during side-by-side walking. As stimuli, we used Point Light Walkers (PLWs) and auralized steps sound; both were constructed from previously captured walking individuals [2][6]. PLWs were retro-projected on a screen and matched according to gender, hip height, and velocity. The participant walked for 7.20m side by side with 1) a PLW, 2) steps sound, or 3) both displayed in temporal congruence. Instruction to participants was to synchronize with the available stimuli. The kinematics of 39 retro-reflective markers attached to the body were gathered by a motion capture system. Preliminary results indicate head and foot synchronization in all conditions, assessed by discrete relative phase. Furthermore, consistent with findings of SMS, synchronization with visual information shows higher variability. In future studies, this paradigm will be improved in order to test for sensory dominance, cue combination, and weighting strategies.

P5.100 BIMODAL INFORMATION INCREASES SPONTANEOUS INTERPERSONAL SYNCHRONIZATION OF GOAL DIRECTED UPPER LIMB MOVEMENTS

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When interacting with each other, people often spontaneously synchronize their movements, e.g. during pendulum swinging, chair rocking [5], walking [4][7], and when executing periodic forearm movements [3]. Although the spatiotemporal information that establishes the coupling, leading to synchronization, might be provided by several perceptual systems, the systematic study of different sensory modalities contribution is widely neglected. Considering a) differences in the sensory dominance on the spatial and temporal dimension [5], b) different cue combination and integration strategies [1][2], and c) that sensory information might provide different aspects of the same event, synchronization should be moderated by the type of sensory modality. Here, 9 naïve participants placed a bottle periodically between two target zones, 40 times, in 12 conditions while sitting in front of a confederate executing the same task. The participant could a) see and hear, b) see, c) hear the confederate, d) or audiovisual information about the movements of the confederate was absent. The couple started in 3 different relative positions (i.e., in-phase, anti-phase, out of phase). A retro-reflective marker was attached to the top of the bottles. Bottle displacement was captured by a motion capture system. We analyzed the variability of the continuous relative phase reflecting the degree of synchronization. Results indicate the emergence of spontaneous synchronization, an increase with bimodal information, and an influence of the initial phase relation on the particular synchronization pattern. Results have theoretical implication for studying cue combination in interpersonal coordination and are consistent with coupled oscillator models.

P5.101 PERIPERSONAL SPACE CAN IMPLICITLY MODULATE OUR PREFERENCE TOWARDS SOUNDS

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Sounds presented close to the head can induce tactile experiences and might trigger feelings that the sounds and/or sound sources are something special to us. We examined whether preference to voices can be modulated by distance between the voices and ear. Self-introductory sentences made by ten speakers were played through a mouth simulator and recorded by a dummy head at the distance of 10 cm (close) or 100 cm (distant) between the mouth and the ear. To manipulate the level of implicitness of the distance cues, the close and distant voices were mixed with the original 'dry' voices at mixing rates of 10% or 50%. In the first experiment, 24 listeners were presented with pairs of close and distant voices of different speakers but of the same gender, and reported which voice they preferred. We found that the close voices were significantly preferred than the distant voices when they were presented at the lowest mixing rate (10%). In the second experiment, we found that other 12 listeners could not tell the differences in intensity and distance between the close and distant voices at the mixing rate of 10%, but they could notice intensity difference between them at the mixing rate of 50%. These results indicate that the preference bias towards the close voices was observed only when the participants did not notice physical differences between the close and distant voices, suggesting that sounds emitted in peripersonal space can implicitly modulate our preference towards the sounds.

P5.102 SELF-MOTION EVOKED FROM THE FAR PERIPHERY

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Motion information can be used to update spatial memory through an estimate of a change in position. When self-motion is generated by optic flow, participants either over or under estimate their change in position depending on their instructions and the speed of motion. The full range of performance can be modeled as a leaky spatial integrator (Lappe et al. 2007). Early studies suggested that peripheral vision was more effective than central vision in evoking self-motion (Brandt et al. 1973) but controlling for retinal area suggests that all retinal areas may be equally effective (Nakamura & Shimojo 1998). Neither study was able to investigate the far periphery. Using a large-field Edgeless Graphics display (Christie, Canada, field of view ±112°) and blocking central (±20 and ±40°) or peripheral (viewing through holes of the same sizes) parts of the field, we compared the effectiveness of different retinal areas at evoking forwards self-motion. Ten participants indicated when they had reached the position of a previously presented target. Three speeds (2,6,10m/s) and five target distances (5-45m) were interleaved to prevent using time estimates. Data were modelled with Lappe's leaky spatial integrator model to estimate gains (perceived/actual distance) and a spatial decay factor. When optic flow was presented only in the far periphery, gains were significantly higher than for the same motion presented full-field or in the central field only. The increased effectiveness of optic flow in the peripheral field alone compared to full-field, suggests an inhibitory interaction between central and peripheral motion.

P5.103 EFFECTS OF VOLUNTARY MOVEMENTS ON SIMULTANEOUS PERCEPTION OF AUDITORY AND TACTILE STIMULI PRESENTED ON NON-MOVING BODY SITE

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When people are voluntarily moving their body sites, the points of subjective simultaneous (PSSs) of auditory and tactile stimuli shift compared to the PSSs without such movement (Kitagawa et al. 2009; Nishi et al. 2014). However, in the previous studies, the tactile stimuli were presented on the body sites, which people were voluntarily moving. This paper aimed to investigate whether voluntary movements influence the PSSs of auditory stimuli and tactile one of the body sites which are not moving. We performed temporal order judgment (TOJ) task in which participants judged which auditory stimuli and tactile one presented on left index finger came first under three movement conditions: 1) voluntary condition where participants performed the TOJ while moving voluntarily their right index fingers, 2) involuntary condition where participants performed the TOJ while their right index finger were moved involuntarily by a device, 3) no-movement condition where participants just performed the TOJ. By performing TOJ task at various stimulus onset asynchronies, we measured PSS in each condition. From the results of preliminary experiments with some participants (N=3), we suspected that the voluntary movements of right index finger affected the PSSs. Although this conclusion still needs to be confirmed with more participants in the following time, this result suggest that voluntary movements of a body site change the temporal integration including tactile stimuli on other body sites.

Keywords: Voluntary movements, Temporal perception, Multi-sensory integration, Temporal order judgment, body site

P5.104 TIME LOADING…THE EFFECTS OF ATTENTIONAL LOAD ON DURATION JUDGMENTS

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Time 'flies' when multitasking and slows down when waiting for the bus. This altered percept of an otherwise physically equal interval has been accounted for by models supporting the emission of pulses by a pacemaker, which are accumulated via the opening and closing of a switch. Differential time percepts are mostly accounted for by a pulse rate of the pacer, which is mainly determined by arousal, and the state of the switch, which is believed to be controlled by attention. In terms of the latter it has been supported that allocation of attention to a secondary task leads to switch "flickering" and, thus, the loss of pulses, which ultimately leads to the underestimation of an interval. It is as yet under-researched, however, which specific attentional processes account for the opening and closing of the switch and whether or not differential degrees of attentional load lead to further interval underestimations. In this study, therefore, we manipulated attentional load during a reproduction task. Specifically, we utilized a visual search task were the targets are 'Ts' of six different colors and two orientations presented in the center of a to-be timed square. Target presentations are in high-load (conjunction search) or low-load (feature search) situations. If the switch is indeed controlled by attention it should lead to larger underestimations as the load increases. Such finding will further define the role of the switch in interval timing but, most importantly, will lead to further investigation of the attentional processes defining our sense of timing.

P5.105 IMPACT PREDICTION BY LOOMING VISUAL STIMULI ENHANCES TACTILE DETECTION IN HUMANS.

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From an ecological point of view, approaching objects are potentially more harmful than receding objects. A predator, a dominant conspecific, or a mere branch coming up at high speed can all be dangerous if one does not detect them and produce the appropriate escape behavior fast enough. And indeed, looming stimuli trigger stereotyped defensive responses in both monkeys and human infants. However, while the heteromodal somatosensory consequences of visual looming stimuli can be fully predicted by their spatio-temporal dynamics, few studies have explored whether visual stimuli looming towards the face predictively enhance heteromodal tactile sensitivity around the expected time of impact and at its expected location on the body. In a recent behavioral study (Cléry et al., 2015), we report that, in addition to triggering a defensive motor repertoire, looming stimuli towards the face provide the nervous system with predictive cues that enhance tactile sensitivity on the face. Specifically, we describe an enhancement of tactile processes at the expected time and location of impact of the stimulus on the face. We additionally show that a looming stimulus that brushes past the face also enhances tactile sensitivity on the nearby cheek, suggesting that the space close to the face is incorporated into the subjects' body schema. We propose that this cross-modal predictive facilitation involves multisensory convergence areas subserving the representation of a peripersonal space and a safety boundary of self.

P5.106 THREAT MODULATES NEURAL RESPONSES TO LOOMING VISUAL STIMULI

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Objects on a collision course with an observer produce a specific pattern of optical expansion on the retina known as looming, which in theory exactly specifies time-to-collision. We recently demonstrated that the affective content of looming stimuli influence perceived time-to-collision, with threatening objects judged as approaching more rapidly than non-threatening objects. Here, we investigated the neural mechanisms by which perceived threat modulates spatiotemporal perception. We recorded the electrical brain activity while participants judged the time-to-collision of threatening or non-threatening stimuli, which expanded in size at a rate indicating one of five time-to-collisions. We analysed event-related potentials (ERPs) and oscillatory neural responses. Consistent with our previous findings, the arrival time of threatening stimuli was underestimated compared to non-threatening stimuli. Further, both speed of approach and threat modulated both ERPs and oscillatory responses from occipito-parietal channels. Critically, however, there was no overlap between which signals were modulated by speed of approach and threat, nor any interactions between these cues. These results are consistent with the interpretation that threat induces a spatio-temporal bias on vision independent of the optical information about looming. Alternatively, interactions between these cues may occur sub-cortically.

P5.107 TEMPORAL FREQUENCY MODULATES AUDITORY SPEED PERCEPTION

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Temporal frequency could be used as a relative cue for auditory speed perception. For example, rubbing our hands against rugged surfaces typically generates sounds whose temporal rates directly correlate with speed: the faster the motion, the higher the temporal frequency of the sound produced by the friction. Previous research in visual motion perception has demonstrated that temporal frequency systematically modulates speed estimation. Here we investigate whether temporal frequency also modulates auditory speed perception. In an immersive virtual auditory space, we played sounds rotating at different speeds around participants' heads. Sounds consisted of pink-noise with sinusoidal amplitude modulation (AM). In a speed discrimination task, participants reported which of two sounds seemed to move faster, while we independently varied both speed of motion and AM frequency across trials. Like in vision, temporal frequency systematically modulates auditory speed perception: the higher the AM frequency, the faster the sound appeared to move. We argue that the origin of this effect might differ between vision and audition. While in vision it depends on the properties of early motion detectors, we suggest that for auditory motion perception the brain implicitly relies on learned natural scene statistics. Assuming an underlying constant environment (e.g. isotropic surfaces), the brain interprets changes in AM frequency in terms of changes in speed. We speculate that origins of such phenomenon rely on learned multisensory correlations across speed of motion and temporal rate of the corresponding sounds occurring in an otherwise constant–or slowly changing–¬environment.

P5.108 KNOW THY SOUND: PERCEIVING SELF AND OTHERS IN MUSICAL CONTEXTS

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This presentation discusses findings from empirical studies that investigated recognition of an action's agent by using music and/or other auditory information. Embodied cognition accounts ground higher cognitive functions in lower level sensorimotor functioning. Action simulation, the recruitment of an observer's motor system and its neural substrates when observing actions, has been proposed to be particularly potent for actions that are self-produced. This presentation examines evidence for such claims from the music domain. It covers studies in which trained or untrained individuals generated and/or perceived (musical) sounds, and were subsequently asked to identify who was the author of the sounds (e.g., the self or another individual) in immediate (online) or delayed (offline) research designs. The presentation is structured according to the complexity of auditory–motor information available and includes experimental work on: 1) simple auditory information (e.g., clapping, piano, drum sounds), 2) complex instrumental sound sequences (e.g., piano/organ performances), and 3) musical information embedded within audiovisual performance contexts, when action sequences are both viewed as movements and/or listened to in synchrony with sounds (e.g., conductors' gestures, dance). The reported findings are examined in relation to cues that contribute to agency judgments, and research concerning audiovisual integration, action understanding, and applied musical practice.

P5.109 AUDIOVISUAL POINT OF SUBJECTIVE SIMULTANEITY (PSS) REFLECTS CUE INTEGRATION UNDER PERCEPTUAL UNCERTAINTY RATHER THAN MODALITY SPECIFIC PERCEPTUAL LATENCY: EVIDENCE FROM ELECTROPHYSIOLOGICAL SOURCE-ANALYSIS (LORETA)

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The point of subjective simultaneity (PSS) is believed to reflect latency differences between modalities and shows high inter-individual variance. We test this for audiovisual stimuli using a spatial temporal-order task (“which side came first”) and randomly presenting four types of stimulus-pairs within a session: unimodal auditory (AA) and visual (VV), and bimodal auditory-first (AV) and visual-first (VA). Our analysis estimated the influence of unimodal trials on the PSS of following bimodal trials. Behavioral results showed the bimodal PSS was biased towards the modality of preceding unimodal trials, with bias-strength correlating with individual task performance. Peak-latencies for a subset of electrodes were puzzling: When comparing congruent versus incongruent trials (e.g., VA preceded by VV versus AA), some electrodes showed decreased and some increased peak-latency. However, a new way of analysis was clearer: Behavioral results were best explained by global-field-latency (i.e., mean of all electrodes) of the N1-P2 flank and its variance (within a given participant), with higher variance for incongruent trials suggesting more complex processing. Applied source-analysis (LORETA) confirmed this pattern and revealed for incongruent trials higher activation in Broadman-Area 8 (known for involvement in cognitive uncertainty) for incongruent trials accompanied with a relatively late increase of source-strengths in sensory cortices (e.g. ~290ms in V1 in condition AA-VA). Our data suggest PSSs result from cue integration (prior trials) scaling with task demands, not latency differences. This agrees with a proposal that high inter-individual variability of PSS reflects integration of internal cues biasing to one of the modalities when perception is uncertain.

P5.110 INVESTIGATING CROSSMODAL INFLUENCE BETWEEN NOCICEPTION AND VISION USING TEMPORAL ORDER JUDGMENTS

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Coordinating spatial perception between external space and body space is essential to adapt behaviors to objects, especially when these objects become noxious. Little is known about the crossmodal link between nociception/pain and vision. This study investigates how a nociceptive stimulus affects the perception of visual stimuli that are presented in the same side of space as the stimulated body part. In a temporal order judgment task, participants judged which of two visual stimuli, one applied to either side of space, had been perceived first. Visual stimuli were presented either near participants' hands (peripersonal) or far from them (extrapersonal). Each pair of visual stimuli was preceded by either one nociceptive stimulus applied on one of the hands (unilateral) or two nociceptive stimuli, one applied to each hand at the same time (bilateral). Results show that, as compared to the bilateral condition, participants' judgments were biased positively to the advantage of the visual stimuli having occurred in the same side of space as the hand on which the nociceptive stimulus was applied. Moreover, this effect seems larger when the visual stimuli were presented close to the hands. These results suggest that the perception of external space can be affected by the occurrence of highly significant bodily sensations such as pain, specifically when external sensory events occur in the peripersonal space.

P5.111 NEURAL CORRELATES OF MULTISENSORY TEMPORAL ACUITY

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Multisensory integration is the ability to combine information from multiple sensory modalities and has been shown to confer numerous behavioral benefits in humans. A primary determinant of multisensory interactions is the temporal relationship between paired sensory inputs, and the temporal binding window (TBW) is a probabilistic construct representing the interval of time in which there is a high likelihood of perceptual fusion between events across modalities. Large individual differences in this measure of multisensory temporal acuity have been reported in both children and adults in a number of studies. Furthermore, deficits in multisensory temporal integration contribute to dysfunction in disabilities such as autism spectrum disorder, dyslexia, and schizophrenia. Here we investigate the neural basis of individual differences in multisensory temporal acuity using a multisensory temporal task in conjunction with high density EEG recording. Whole brain topographic analysis revealed that differences in neural generator configuration during perceptual processing were related to individual temporal sensitivity. Individuals with narrow TBWs, and thus high temporal acuity, had faster transitions to a sequentially second functional microstate. The overall duration of the later microstate was likewise longer in individuals with narrow TBWs. These results provide evidence that latency of neural generator recruitment corresponds with individual perceptual thresholds during a temporal task.

P5.112 DISTORTIONS OF PERCEIVED TIMING IN REGULAR SEQUENCES

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Despite being an objective unit of measurement, time is subject to perceptual distortions due to sensory information, prediction and attention. The present study targeted how temporal predictability has an impact on perceived timing and how sensitivity to temporal deviations influences the timing of the last stimulus in a regular sequence. In Experiment 1, we presented sequences of 3, 4, 5 or 6 stimuli either in separate blocks or interleaved. Participants reported whether the timing of the last stimulus was either 'early' or 'late' relative to their expected regular timing. Results indicated an increased temporal sensitivity with longer sequences in the interleaved condition and a generally better discrimination performance in the blocked condition. Further, we found that stimuli were perceptually accelerated more when sequences were presented interleaved. In Experiment 2, we presented 6-stimulus sequences with an anisochrony happening at either the 3rd, 4th, 5th, or 6th position. Participants were asked to report which stimulus was deviant. Results indicated perceptual acceleration for the 3rd, 4th and 5th stimuli but not for the last stimulus, which was instead perceptually delayed. We explain these results with a Bayesian model where perceived timing is the combination of current sensory information with a-priori knowledge about when a future stimulus is likely to occur based on the regularity of the sequence and when a sequence is likely to end based on the previous sequence lengths.

P5.113 TRANSACCADIC SPATIAL STABILITY AND PRE-SACCADIC PERCEPTION

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Eye movements pose major problems to the visual system, because each new saccade changes the mapping of external objects on the retina. While continuously visible objects are perceived as stable in spite of the displacement of their retinal image, perisaccadic flashes are mislocalized – usually compressed toward the saccade target. We investigated the relationship between these two phenomena. Our results show that a stimulus flashed just before saccade onset can be drawn toward another flashed stimulus presented pre-or post-saccadicaly. The interaction field is oriented along the retinotopic trajectory of saccade-induced motion, which suggests a

spatiotopic mechanism for trans-saccadic integration, consistent with the properties of ""remapping cells"". Both flashed stimuli and stable visual references exert a powerful influence over perisaccadic localization, which can be interpreted as the signature of trans-saccadic spatial binding for the same object. We jointly test the two phenomena in a condition where visual references can be tightly controlled: a dark anechoic room. In complete darkness with acoustic-driven saccades, both the compression toward the saccade target and the interaction between perisaccadic flashes decreases dramatically. This suggests a strong link between transient perisaccadic illusions and the stability of perception for the rich visual scene we are usually exposed to.

P5.114 SPATIOTOPIC MAPS DURING HEAD TILT

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It is remarkable how our perceptual experience of the world remains stable, despite continuous head and eye movements. Much work has concentred on stability in the face of saccadic eye-movements, few studies have examined the mechanism that build an allocentric reference frame despite continuous head movements (Mikellidou et al, JOV, 2015). Head rotations in the horizontal and sagittal plane are almost completely counteracted by the vestibular-ocular reflex. However, tilting the head in the frontal plane is only partially counteracted by torsional eye-movements, and therefore causes the retinal image to tilt: yet we are largely unaware of the tilting of our image of the world as we tilt our heads. One possible mechanism aiding perceptual stability is that the brain actively constructs a spatiotopic map of the world, anchored in external coordinates. Previous studies have shown that the positional motion aftereffect (pMAE), apparent change in position after adaptation to motion, is spatially selective in external rather than retinal coordinates, when a saccade occurs between adaptation and test (Turi & Burr, Proc. Roy. Soc.,2012). Using a similar technique we show that the pMAE is spatially selective in external coordinates when subjects make a head tilt resulting in image-tilt of 38 degrees (measured by an afterimage technique). This result supports further the notion that perceptual stability is at least partly maintained by constructing spatiotopic maps of the world, which can be influenced by image motion.

P5.115 AUDIO-VISUAL TEMPORAL-ORDER JUDGMENT REVEALS RHYTHMIC OSCILLATIONS IN TEMPORAL BIAS

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Neural oscillations are ubiquitous brain phenomena that modulate a wide range of brain functions, including perception, attention and memory. Evidence suggests that time perception is also closely linked to endogenous oscillatory activity and that brain oscillators plays a crucial role in modulating our internal clock, and thus our sense of time. In the present experiment, we studied the effects of visual oscillations on time perception, by measuring audio-visual temporal-order judgment (TOJ). 7 volunteers initiated the trial sequence by button-press, and after a random delay (0-500 ms) the audio-visual sequence was presented: a Gaussian-blob (duration 8 ms, diameter 5°), preceded or followed by a short noise-burst (duration 8 ms) at variable SOA (±16-260 ms). Start and response button-presses had to be continuously spaced within 1.5-3.0 seconds (0.3-0.6 Hz), resulting in a continuous rhythmical tapping. In each block ~20% of the stimuli were presented before the participants' start signal. Results show that motor-action had strong effects on perceived simultaneity: stimuli presented before button-press were perceived simultaneity when they were physically simultaneous; after action execution auditory stimuli needed to be advanced by ~40 ms in order to be perceived simultaneous with vision, pointing to a strong sensory-motor interaction. In addition, PSE rhythmically oscillates in synchrony with the button-press, at ~10 Hz over a range of about 500 ms, including trials presented before the action. Taken together, these findings provide psychophysical evidence that neural oscillations are strongly related to time perception, and provide new insights in understanding the temporal dynamics of audio-visual integration processes.

P5.116 AUDITORY EVENTS NEAR TARGET APPEARANCE MODULATE SACCADE ONSET, NOT VISUAL EVENTS

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Measuring saccade onset allows estimating small changes in processing time between particular conditions. Saccade reaction times are used to study a wide range of behaviors including attention, motor adaptation, gain or variability reinforcement. In this project we explored weather auditory events could modulate saccade onset.Participants performed thousands of saccades toward targets appearing to the left or to the right of a fixation point, while recording eye-movements at 1000Hz. A short beep was delivered in temporal vicinity of the target appearance (SOA between –240ms and +240ms). We found that early beeps largely reduced saccade onset while late beeps tended to delay saccades. This modulation pattern is compatible with audiovisual temporal integration described in the

literature. In order to control for possible priming effects, we conducted a similar control experiment in which the auditory event was replaced by a visual event (small but noticeable decrease of the background luminosity lasting 10ms). We found increases in saccade latencies right before and after audiovisual synchrony much as in a forward and backward masking. More importantly, the decreased latency measured before the forward masking peak (beep leading) was strongly reduced compared to the first experiment, suggesting that the later was not due to a priming effect but rather to a low-level audiovisual integration mechanism.

P5.117 SIMULTANEITY JUDGMENTS IN THE CONTEXT OF AN ACTION OUTCOME

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The question of how voluntary actions influence the processing of perceptual events has been investigated unimodally up to now. However, since our actions usually have multisensory consequences, the relationship between voluntary actions and their multisensory outcomes are yet unclear. In a behavioral experiment, we assessed the influence of predictive mechanisms on simultaneity judgments of audiovisual stimuli. Our aim was to investigate whether audiovisual simultaneity judgments would change when the action-outcome relationship was violated. Accordingly, participants had to make simultaneity judgments for audiovisual stimuli triggered by their button presses. We manipulated temporal congruence by introducing three (0, 417.5, 2500 milliseconds) delays between participant's button press and the occurrence of audiovisual stimuli. Analysis of the fitted simultaneity judgment curves revealed that window-limits (decision boundaries to judge stimuli as simultaneous) for the 0 delay condition were significantly wider than window-limits for other delay conditions. In other words, participants became more sensitive to audiovisual asynchronies when there was a delay between their action and the perceptual outcome. There was no difference between the intermediate and the long delay. We also replicated the general finding that audiovisual simultaneity is asymmetrical, where the visual leading side of the curve had a higher window-limit than the auditory leading side of the curve. Our findings showed that asynchronies between audiovisual stimuli contingent upon voluntary actions are tolerated more, suggesting that sensory suppression due to predictive mechanisms is not limited to unimodal stimuli, but extends to multisensory consequences of actions.

P5.118 BEHAVIORAL EVIDENCE OF A SHARED NUMEROSITY REPRESENTATION BETWEEN PERCEPTION AND MOTOR SYSTEMS

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Recent neurophysiological studies have reported numerosity-selective neurons in the parietal and frontal cortex of monkeys whose response is independent of the sensory modality of the stimuli, presentation format, and are also selective to repetitive motor patterns (Sawamura et al., 2002). Recently Arrighi et al. (2014) provided behavioural evidence supporting this idea of a generalized sense of number by showing that numerosity adaptation occurs cross-modally (from vision to audition and viceversa) and across stimuli presentation format (sequential to simultaneous). Adapting to slow sequences of numbers (2 Hz) increases the apparent numerosity, while adapting to fast sequences (8 Hz) decreases apparent numerosity. Here we extend these findings to show that: 1) numerosity adaptation also occurs within the tactile domain 2) tactile numerosity adaptation affects both visual and auditory numerosity estimates 3) visual and auditory numerosity adaptation affects tactile numerosity estimation. 4) self-producing a sequence of motor actions (finger tapping) without tactile feedback (no finger/surface contact during the motor routine) also causes adaptation of numerosity estimation of visual stimuli. Taken together these results point to the existence of a general mechanism to represent number in the brain that is amodal (independent from the sensory modality), independent of format and also shared between the perceptual and the motor systems.

P5.119 EFFECTS OF MOTION DURATION ON CAUSAL INFERENCE IN MULTISENSORY HEADING ESTIMATION

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It has been shown repeatedly that visual and inertial sensory information on the heading of self-motion is fused by the CNS in a manner consistent with Bayesian Integration (BI). However, a few studies report violations of BI predictions. This dichotomy in experimental findings previously led us to develop a Causal Inference model for multisensory heading estimation, which could account for different strategies of processing multisensory heading information, based on discrepancies between the heading of the visual and inertial cues. Surprisingly, the results of an assessment of this model showed that multisensory heading estimates were consistent with BI regardless of any discrepancy. Here, we hypothesized that Causal Inference is a slow-top down process, and that heading estimates for discrepant cues show less consistency with BI when motion duration increases. Six participants were presented with unisensory visual and inertial horizontal linear motions with headings ranging between ±180°, and combinations thereof with discrepancies up to ±90°. Motion profiles followed a single period of a raised cosine bell with a maximum velocity of 0.3m/s, and had durations of two, four, and six seconds. For

each stimulus, participants provided an estimate of the heading of self-motion. In general, the results showed that the probability that heading estimates are consistent with BI decreases as a function of stimulus duration, consistent with the hypothesis. We conclude that BI is likely to be a default mode of processing multisensory heading information, and that Causal Inference is a slow top-down process that interferes only given enough time.

P5.120 AUDIOVISUAL SIMULTANEITY IN A TIME TO COME

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Audiovisual temporal order judgments are renown to be difficult. Several theories hypothesise what are the limiting factors in this task. Here we attempt to influence judgments and improve discrimination by exploiting the predictions about when a sensory event is bound to occur. Subjects judged whether a change in the trajectory of a moving visual stimulus preceded or followed the onset of a brief sound. In one condition the two events took place at an unpredictable time, while in another condition there was a cue indicating the location of the change in trajectory, leading to a predictable timing of the event. We show that such a spatial cue led to a better performance in temporal order judgments. We also show that the improvement depended on the reliability of the visual cue. Moreover, we find that in some cases perceived simultaneity could be affected by discrepancies between the location of the cue and the actual location of the change in trajectory. We conclude that the brain is capable of exploiting spatial cues for the prediction of stimulus timing and this can improve the precision of temporal order judgments. Such predictions can be seen as the a-priori probability of when an event is about to happen, which guides the deployment of attentional resources and also influences perception as it is integrated with the incoming sensory information.

P5.121 ASSESSMENT OF AUDITORY SENSITIVITY BY MEANS OF TARGET TRACKING

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Traditional psychophysics usually uses simple but often boring tasks, which are rigorous but require many trails and are often too time-consuming for novices, young participants and patients. In this study we adapted a novel technique (Bonnen et al 2015, JOV) devised for measuring precision of visual judgements to measure auditory spatial thresholds. Subjects were asked to track continuously a moving visual or auditory target, which made a random walk, produced by randomly changing velocity or acceleration each frame. Even a brief session of 45 seconds yields sufficient information to compute a performance measure. Performance was computed by cross-correlating the tracked with the physical position, over time. The cross-correlograms were well fitted with a gaussian function, whose mean and standard deviation provide an estimate of the lag and extent spatial pooling of information over time. We found that both parameters correlated with each other (R–square= 0.47), and also with traditional psychophysical measures of human spatial sensitivity (R–square = 0.71). Also visual measures and auditory measures were highly correlated (R–square = 0.79). These results show that a technique pioneered for visual research is also effective for auditory space perception, reducing considerably the time required to assess spatial sensitivity compared with traditional psychophysics. Because the task is fast, easy, and enjoyable, it can be applied to measure auditory spatial sensitivity in children, in the blind and in other clinical patients who find traditionally tasks too taxing.

P5.122 CHANGES IN PERCEIVED VISUAL TIME DURING RHYTHMIC MOTOR BEHAVIOR

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Temporal processing is fundamental for generating movement sequences as well as for accurately synchronizing motor behaviors with relevant sensory inputs. Growing evidence suggests a tight link between sensory timing functions and motor processing (Yarrow et al., 2001, Morrone et al., 2005, Tomassini et al., 2014). Here we investigated this relation by measuring perceived visual time during rhythmic motor behavior. Participants listened to four auditory tones played at 1 Hz and continued the sequence (without auditory feedback) by tapping four times with their index finger at the same temporal rate as sound presentation. At random times between the third and the fourth finger taps participants were presented with two visual flashes, marking an empty interval (centered around 150 ms), and were asked to judge their temporal separation. When stimulus presentation time is aligned to the motor acts, its perceived temporal separation changes in a non-monotonic fashion. Three major variations can be observed: perceived time shows maximal expansion in the middle of the inter-tap interval (~ 0.5 s; i.e., halfway from two consecutive finger taps), and two peaks of perceived compression just after (~ 0.15 s) and just before (~ -0.15 s) the finger taps. These results suggest a common sensori-motor clock that might be used both

to tell the time of sensory events as well as to track the time passed from a motor response (and/or the time remaining for the next motor response).This mechanism might help to set a unified temporal frame for the effective coordination of the action-perception loop.

P5.123 THE FLASHED FACE DISTORTION EFFECT OCCURS ONLY WHEN DIFFERENT IDENTITIES ARE DISPLAYED

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In 2011 Tangen et al. described a face distortion effect that resulted from the rapid sequential presentation of spatially aligned faces (the flashed face distortion effect, or FFD; Tangen JM, Murphy SC, Thompson MB, 2011, Perception 40, 628-30). It was argued that the FFD was driven by an adaptive mechanism sampling over time to encode the current image relative to the preceding images. A critical question is whether the FFD results from variation between different visual images or variation between different people's faces. Here we demonstrate that the FFD is reduced when presenting multiple images of the same person (despite gross variation between the images) compared to presenting multiple images of different people. The implication is that the underlying mechanism is sensitive to face identity.

P5.124 OPTIMAL RANGE OF MULTIMODAL INTEGRATION IN PERCEIVING DIRECTION OF SELF-MOTION FROM VISUAL AND VESTIBULAR STIMULATION.

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We previously reported multimodal integration in perceived self-motion direction resulting from simultaneous presentation of visual and vestibular stimuli (Sakurai et al., 2002, 2003, 2010, 2011). For example, when observers passively experience real linear oscillatory leftward/rightward somatic motion while viewing expanding/contracting visual optic-flow patterns consistent with forward/backward body motion, their perceived self-motion direction is intermediate to those specified by visual and vestibular information individually. We investigated the limit of this integration by introducing angular differences of body-motion direction from visual motion direction. Observers seated on a rotatable chair on a motor-driven swing and wore a head-mounted display. The visual stimuli consisted of translating vertical sine-wave gratings phase-locked to the swing motion. The vestibular stimuli consisted of somatic oscillatory motion with one of 7 directions (0, 30, 60, 90, 120, 150, 180 deg) of the chair. The observers' leftward/rightward somatic motion and its phase were congruent with the visual stimuli in 0 deg condition, while they were incongruent in other conditions. Observers were sound-cued to indicate their perceived direction of self-motion via a rod-pointing task. One remarkable result is that most observers' direction judgments showed vestibular dominance in 30 deg condition although their judgments were intermediate to those specified by visual and vestibular information in 60 and 90 deg conditions, suggesting that multimodal integration is a weighted combination of visual and vestibular cues. In other conditions (120, 150, 180 deg), some observers' judgments were vision-only or vestibular-only, suggesting that multimodal integration in this context is an either-or process for these observers.

P5.125 VISUAL LANDMARK DISPLACEMENTS ACROSS SACCADES ALSO SHIFT AUDITORY LOCALIZATION

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The presence of a visual stimulus both before and after an eye movement has been shown to act as a visual landmark for spatial perception (Deubel, 2004). When this landmark is undetectably shifted during an eye-movement then visual localisation is found to shift proportionately, indicating that visual space is aligned to the landmark. Here we investigated auditory and visual localisation by presenting two brief visual (LED) or auditory (white noise) probes at different locations before and after a saccade. Manipulating the pre- and post-saccadic probe locations allowed the precision and accuracy of stimuli localisation to be measured. Additionally, the visual landmark could either remain stationary or be displaced during the eye-movement to evaluate its role as an anchor for visual and auditory space. In agreement with previous findings, we found a proportional shift in visual stimuli localisation with landmark displacement. Importantly, there was also a half-proportional shift in auditory stimuli localisation relative to the landmark displacement, despite the head and ears remaining stationary. This indicates that even when pre- and post-saccadic sounds originated from the same location the shifting of the visual landmark caused the sounds to be perceived as originating from distinctively different locations. This modulation of auditory space by a visual landmark suggests that the locations of targets across modalities may be encoded within a common cross-modal spatial map. Such a framework could allow different unimodal stabilising mechanisms to benefit all the senses and assist in the maintenance of a stable multisensory spatial percept.

POSTER SESSION 6: CROSS-MODAL INTEGRATION

P6.126 SELECTIVE INFLUENCE ON MULTISENSORY ENHANCEMENT UNDER LOAD CONDITIONS

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Stimuli processing in one modality can benefit from other stimuli which were presented simultaneously from another modality. In the present study, we investigated whether the multisensory benefit from another modality was modulated by working memory load. Faces and voices were presented in three conditions: (1) Face only; (2) Voice only and (3) Face-Voice. Participants performed a gender discrimination task while holding in working memory a sequence of digits (in Experiment 1) or orientation of lines (in Experiment 2). The multisensory benefit was calculated by the differences of reaction times between the unimodal (either visual or auditory) and bimodal conditions. For auditory stimuli, the multisensory benefit was observed for both load conditions. However, this effect was significantly larger in the high load condition than in the low load condition in Experiment 1, while not influenced by the load in Experiment 2. For visual stimuli, the multisensory benefit was not observed both in Experiments 1 and 2. Our results supported that the multisensory benefit was affected by the specific types of working memory. Moreover, in some circumstances, the auditory stimuli benefit more from the simultaneous visual stimuli than vice versa.

Keywords: multisensory benefit; working memory; load; visual; auditory

P6.127 MULTISENSORY GAIN: BEHAVIOURAL INVERSE EFFECTIVENESS OR STOCHASTIC RESONANCE?

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Multisensory integration is expected at its highest when the quality of unisensory stimulation is at its lowest. This is known as inverse effectiveness (IE), a principle inspired by neuronal findings and replicated at behavioral experimentation. The latter findings, however, have been a matter of debate given the neuronal basis of the principle and recent data resulting not in a linear inverse pattern but an inverted U instead. In light of these findings we investigated, for the first time, whether the observed multisensory gain (MG) is best accounted for by stochastic resonance (SR), a nonlinear phenomenon where the addition of noise can improve weak stimulus detection, rather than IE. Additionally, we examined MG in the presence of both visual and auditory signal degradation using more naturalistic types of noise and all possible signal degradations. We conducted, therefore, an experiment where we assessed syllable detection at various levels of auditory, visual, and audiovisual ambiguity. The stimuli were created using Synface with five different levels of: a) articulation ambiguity by modulating the opening of the mouth and the associated facial muscles and b) auditory speech ambiguity, using a noise excited vocoder, which retains the spectral envelope of the signal but replaces the sound source with noise. Results indicate that behavioral IE describes the mean MG as a function of visual ambiguity in syllable articulation. Similar patterns were obtained for audio noise. Sub-groups with a few individuals that deviate from the observed IE patterns suggest that further research is required.

P6.128 SALIENCE EFFECTS CROSSMODAL INTERACTIONS (I): AUDITORY SALIENCE SWITCHES CROSSMODAL INTERACTIONS FROM BENEFICIAL TO DETRIMENTAL

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Auditory information can improve visual processing (for example, Caclin, et al., 2011; Gleiss & Kayser, 2014, Lippert et al., 2007, McDonald et al.,2000; Strömer et al., 2009). Ciaramitaro & Dobkins (in prep) find enhanced visual detectability when a salient sound oscillates out-of-phase (OP), but not in-phase (IP), with visual information in 3-month-olds and adults. Given such a counter-intuitive result, one would predict enhanced processing for IP interactions, we examined how auditory salience may modulate crossmodal influences on near-threshold visual detectability by considering more versus less salient sounds. We used a two-alternative forced choice procedure to measure visual detection thresholds (75% correct). On a given trial, the visual stimulus, presented left or right of monitor center, fluctuated in luminance at 1 Hz from background grey to one of five possible maximum contrasts. A concurrent, non-lateralized task-irrelevant, auditory white noise stimulus was presented, modulating in loudness at 1 Hz, under two auditory salience levels (1) high-salience (60 dB) or (2) low-salience (35dB), and two temporal levels: fluctuating in-phase (IP) or out-of-phase (OP) with the visual stimulus. Subjects report of detecting the visual stimulus was quantified as first look, recorded via eye tracker. We found when auditory salience was high, visual OP thresholds were improved relative to IP, replicating our previous findings, whereas in the low-salience condition, visual IP thresholds were improved relative to OP. Within the same observer, we show that auditory salience can reverse the in-phase benefit commonly predicted from synchronous crossmodal interactions.

P6.129 PUPIL DILATION: A NOVEL ECOLOGICAL MEASURE FOR MULTISENSORY INTEGRATION? A PRELIMINARY REPORT

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Detecting and integrating information across the senses is an advantageous mechanism for enhancing stimulus detection in space and time. Behavioural studies recording manual reaction times (RT) revealed that participants are systematically faster at responding when an auditory and a visual stimulus are simultaneously presented compared to when they are presented alone. This study aims to explore a novel way for measuring audio-visual integration that could be applied as an elective tool in developmental population; pupil dilation. Changes in pupil diameter occur spontaneously during stimulus presentation, do not require overt responses, and provide an automatic measure of attention and cognitive load. However this non-intrusive and ecological measure has not yet been implemented in the study of multisensory integration. We recorded pupil dilation responses with an infrared eye-tracking device (Tobii X-300) and presented participants (N=32) with a series of shapes and sounds either alone or simultaneously. On a separate block, we asked the participants to manually respond to the same stimuli as fast as possible. The preliminary results indicate i) faster RTs and ii) larger pupil diameter to the combination of audio-visual stimuli, and iii) a moderate correlation between these two measures. Pupil dilation might be used to investigate multisensory processes and this study will serve as a foundation for the investigation of the origin and development of audio-visual integration early in infancy. That is, while RTs cannot be collected in infants, pupil dilation might provide us with a novel measure to study the development of multisensory integration.

P6.130 VISUO-HAPTIC AND HAPTIC-HAPTIC LOCATION MATCHING ARE CONSISTENT OVER TIME

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When subjects reach for a visual target with their unseen dominant hand, they make systematic errors. They also make errors when reaching for their other hand, a haptic target. In this study, we investigated whether these visuo-haptic and haptic-haptic matching errors are consistent over time. In a reaching task, subjects had to reach for either visual targets or haptic targets without any feedback except for their own proprioception. This was repeated within each session and in five additional identical sessions. There were fixed time intervals between the sessions. Each interval was about 5 times larger than the previous one, starting with an interval of 5 hours, then 24 hours, 5 days, and 24 days. To quantify the consistency of the matching errors between the sessions we came up with a 'consistency value', which takes into account both the magnitude and the direction of matching errors. The results show that the magnitude of the systematic errors was similar for both types of reaching tasks. Most importantly, the individual systematic errors were consistent throughout the 24 days, although they differed between subjects. This implies that measured systematic visuo-haptic and haptic-haptic matching errors could be compensated for in the design of interfaces for technical devices.

P6.131 VISUAL AND TACTILE ATTENTIONAL RESOURCES ARE SHARED IN SUSTAINED SPATIAL TASKS AND HIGH ATTENTIONAL LOAD DOES NOT DISRUPT VISUOTACTILE INTEGRATION

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Human information processing is limited by attentional resources. Two questions that are discussed in multisensory research are 1) whether there are separate spatial attentional resources for each sensory modality and 2) whether multisensory integration is influenced by attentional load. We investigated these questions using a dual task paradigm: Participants performed two spatial tasks (a multiple object tracking task and a localization task) either separately (single task condition) or simultaneously (dual task condition). In the multiple object tracking task, participants visually tracked a small subset of several randomly moving objects. In the localization task, participants either received visual, tactile, or redundant visual and tactile location cues. In the dual task condition, we found a substantial decrease in participants' performance and an increase in participants' mental effort (indicated by an increase in pupil size) relative to the single task condition. Importantly, participants performed equally well in the dual task condition regardless of whether they received visual, tactile, or redundant multisensory (visual and tactile) location cues in the localization task. This result suggests that having spatial information coming from different modalities does not facilitate performance, thereby indicating shared spatial attentional resources for the tactile and visual modality. Also, we found that participants integrated redundant multisensory information optimally even when they experienced additional attentional load in the dual task condition. Overall, findings suggest that 1) spatial attentional resources for the tactile and visual modality overlap and that 2) the integration of spatial cues from these two modalities occurs at an early pre-attentive processing stage.

P6.132 SALIENCE AFFECTS CROSSMODAL INTERACTIONS (II): ARE VISUAL AND AUDITORY SALIENCE EQUALLY EFFECTIVE AT SWITCHING CROSSMODAL INTERACTIONS FROM BENEFICIAL TO DETRIMENTAL?

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Audio-visual (AV) interactions are not always complimentary, or equally effective in either direction (for example, motion aftereffects: Kitagawa & Ichihara, 2002; Jain et al, 2008; perceived stimulus intensity: Odgaard et al, 2003; 2004). Ciaramitaro & Chow (IMRF, 2015) report enhanced visual processing can depend not only on AV synchrony, but on auditory salience. It is not known if visual salience may act in a similar way, leading to beneficial or detrimental AV interactions. Here we examine how visual salience may modulate crossmodal influences on near-threshold auditory contrast detectability. We used a two-alternative-forced-choice procedure to measure auditory detection thresholds (75% correct performance). On a given trial, an auditory white noise, presented from a left or right speaker, fluctuated in loudness at 1 Hz to one of five possible maximum contrasts against a background static white noise (34 dB). A concurrent, non-lateralized, task-irrelevant, visual stimulus was presented, modulating in brightness from background grey to a specified brightness level at 1Hz, under two visual salience levels: (1) high-salience (140 cd/m2) or (2) low-salience (70 cd/m2), and two temporal levels, fluctuating in-phase (IP) or out-of-phase (OP) with the auditory stimulus. Subjects' report of detecting the auditory stimulus was quantified as first look, recorded via eye tracker. Despite using methods complimentary to our visual detection experiment, here we found no consistent difference in auditory detection thresholds between IP and OP conditions, or high and low visual salience, suggesting that visual and auditory salience do not act in a similar way to influence crossmodal interactions.

P6.133 FREQUENCY-DEPENDENT MULTISENSORY INTERACTIONS IN THE PERIPHERY

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Temporal coincidence of multisensory stimuli has been shown to provide perceptual enhancement. For example, a flash presented simultaneously with a beep will appear brighter than a flash presented in isolation. Research investigating these multisensory enhancements has typically focused on single isolated events. However, in the real world we often encounter repeating trains of multisensory events dispersed throughout the visual field. Here, we demonstrate auditory influences on visual flicker detection that is specific to eccentricity, frequency, and temporal phase. Participants performed a 2-inteval-forced-choice visual flicker detection task at 3Hz, 6Hz, and 12Hz both foveally and peripherally; the detection threshold was measured in terms of the minimum luminance modulation required. On each trial, an amplitude-modulated (AM) sound, either in-phase or out-of-phase with the flicker, was presented randomly in the flickered or static interval. As a control condition, continuous sound was presented in both intervals. Compared with the control condition, AM sounds presented in the static intervals degraded flicker detection for all frequencies, suggesting that AM sounds triggered illusory flashes in static stimulus. In contrast, AM sounds presented in the flicker intervals improved flicker detection when in phase but degraded it when out of phase, selectively for lower frequencies (3 and 6 Hz). All crossmodal interactions occurred only for peripheral presentations. These results suggest that AM sounds influence peripheral vision in two ways, one by generating an appearance of visual flicker, and the other by modulating low-frequency visual flicker in a phase-specific manner.

P6.134 AUDITORY PINOCCHIO: RISING PITCH INDUCES FELT ELONGATION OF FINGER

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Representation of the body is highly plastic, with touch, vision and proprioception contributing to changes in body representation. It has recently been shown that sounds that are congruent with bodily movements performed by the subject can also affect body representation. What is not known is whether non-ecologically valid sounds can alter body representation also. Using the known cross-modal correspondence between rising pitch and upwards motion and between falling pitch and downwards motion, we investigated whether these non-action related auditory stimuli prompt changes to proprioception of the human hand and modulate body representation. Across different trials, participants were presented with auditory input rising in pitch, falling in pitch or with a constant pitch, while applying pressure to and pulling on their occluded right fingertip with their left hand. The effect of sound on perceived finger length was measured by having participants adjusting two visual points to match the felt position of their right fingertip and knuckle and by answers to a questionnaire. Results showed that participants estimated their finger as longer during the rising pitch condition, as compared to the other conditions, and these changes positively correlated with self-reports of finger elongation. Overall, participants reported a sensation of finger elongation for the rising pitch condition and a sensation of finger shortening for the falling pitch condition. Altogether these results add an important addition to the literature on body plasticity, showing that artificial sounds congruent with an accompanying action can induce changes in the mentally represented body size.

P6.135 RELIABILITY BASED REWEIGHTING OF VISUAL AND VESTIBULAR CUES DURING AMPLITUDE DISCRIMINATION

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When navigating through our environment our brain needs to infer how far we moved and in which direction we are heading. In inferring self-motion, the brain combines information from various sensory modalities, predominantly visual and vestibular. Studies have shown that visual and vestibular cues are combined by weighting them in proportion to their reliability, consistent with statistically optimal integration. Although self-motion consists of both heading and magnitude, current research on multisensory integration during self-motion has mainly focused on heading estimation. In this study we investigate whether the brain optimally integrates visual and vestibular information during an amplitude discrimination task. We tested two fundamental predictions of optimal integration, namely; optimal reduction of variance by combining multiple cues and dynamic reweighting based on cue reliability. Participants were seated on a linear sled embedded in a virtual reality environment. They were subjected to a passive linear motion involving visual and vestibular cues with different levels of visual coherences to change visual cue reliability. Participants performed a two-interval two-alternative forced-choice task, indicating which of two sequential displacements was larger. Preliminary results show that humans rapidly reweight visual and vestibular information in proportion to their reliability. These results suggest that humans also optimally integrate visual and vestibular cues in perceiving the amplitude of self-motion.

P6.136 THE EFFECTS OF VISUAL INFORMATION THAT CLAPPING HANDS ON LOUDNESS DISCRIMINATION

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Purpose: We investigated whether visual stimulation that size and speed of movement affects discrimination of loudness. Method: Three videos that the person clapped his hands were presented as visual stimuli. We manipulate the intensity of visual stimuli that changed length between hands and speed of clapping hands. Sounds of clapping hands were presented as audio stimuli, and their loudness levels were manipulated. The video that projected only the fixation point was used as control condition. Condition of audio stimulation was seven volume levels. Participants judged which sounds was louder than the other when two sounds with or without visual stimuli were presented one by one. Result: Visual stimulation that size and speed of movement affects discrimination of loudness was observed. Some the participant felt the sound became louder when the clapping video that bigger size and faster speed of movement was presented, but they tended to feel loudly when presented video projected only the fixation point. Others the participant felt the sound became more quiet when the clapping video that bigger size and faster speed of movement is presented. The others participants felt sound louder when presented video that projected only the fixation point than clapping. Discussion: The results suggested that the person felt louder sounds with visual stimuli than without visual stimuli, and different strategies that participants used related to individual differences in the effect of size and speed of movement.

P6.137 THE ROLE OF PRESTIMULUS OSCILLATORY POWER AND FUNCTIONAL CONNECTIVITY IN THE SOUND-INDUCED FLASH ILLUSION

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In the sound-induced flash illusion (SIFI), a single flash that is accompanied by two brief tones is perceived as two flashes in some, but not all trials. Contrasting neural activity between illusory and non-illusory trials can yield insights into the processes underlying multisensory perception. While poststimulus neural responses during the SIFI are relatively well characterized, there are only few studies that investigated how local oscillatory processes and network activity influence upcoming multisensory perception. Recent studies suggest that power in primary sensory and multisensory areas predicts multisensory perception and indicate that functional connectivity between these areas might play an important role therein. Here, we measured EEG in healthy participants during the SIFI. Activity at the source level was reconstructed using linear beamforming and analyzed for prestimulus oscillatory power differences in auditory, visual and multisensory areas between illusory vs. non-illusory trials. Moreover, we analyzed functional connectivity within a network spanning primary sensory auditory, visual and multisensory cortical areas. Our analysis of local cortical activity revealed stronger alpha-band power in the auditory cortex around 200ms before the onset of non-illusory compared to illusory trials. Strong alpha-band power has been linked to low cortical excitability. Hence, our findings potentially reflect that prestimulus excitability in auditory cortex facilitates multisensory perception. The outcome of the analysis of functional connectivity will also be reported. The present findings further our understanding of the influence of local cortical activity and integration within distributed networks on upcoming perception.

P6.138 MATURATION OF MULTISENSORY INTEGRATION IN TRISENSORY NEURONS: A NEUROCOMPUTATIONAL STUDY

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Superior colliculus (SC) trisensory neurons can learn to apply two different integrative operations to their inputs: a superadditive/additive operation to cross-modal inputs they have experienced as co-varying, and an averaging operation to those they have not. Here we describe how this dual implementation arises from the dynamics of our computational model previously used to describe the maturation of bisensory neurons (Cuppini et al, 2011, 2012). Here averaging is the ""default"" multisensory operation that is preserved in the absence of sensory experience (and matches the operation applied to within-modal stimulus pairs). Although the SC receives its different sensory inputs from many sources, the covariant cross-modal experience preferentially strengthens a specific set of those: inputs from association cortex. It does so via adaptive Hebbian mechanisms, thereby enabling superadditive/additive operation in the target SC neuron. When this learning rule is applied during training, only the cortical inputs matching the experienced pairings are strengthened; consequently, the trisensory neuron only efficaciously integrates those pairs – it continues to average the others. The key feature of the model that explains this empirical result is that the dual operations -- superadditive/additive enhancement vs. averaging -- are actually applied to different tectopetal input pathways (cortically-derived and not). Thus, the key insight of the model is that although the visual, auditory, and somatosensory responses of an SC neuron may be similar in magnitude and timing, the inputs driving them are very different, and the input sources are critical determinants of the products resulting from their synthesis.

P6.139 SENSORY DEGRADATION, BUT NOT PERCEPTUAL LOAD, IMPACTS CROSS-MODAL SELECTIVE ATTENTION

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The differing impacts of data and capacity limits, indexed by sensory degradation and perceptual load respectively, have recently been demonstrated in the visual domain (Lavie & De Fockert, 2003). Data limits appear to increase distractor processing (Yuval-Greenburg & Deouell, 2009), while capacity limits may decrease distractor processing, although the relationship is not clear (e.g., Macdonal & Lavie, 2011 vs. Tellinghuisen and Nowak, 2003). The main aim of the current study was to directly compare the impact of data and capacity limits on cross-modal distractor processing. Our results demonstrate that while data limits increased cross-modal distractor processing, perceptual load failed to modulate distractor processing. These findings do suggest some difference in the impact of data and capacity limits on cross-modal distractor processing, however the effect of capacity limits are in direct contrast to those found in the visual literature. While data limits seem to operate in a similar manner within and across modalities, we correlated performance on the cross-modal task with a unimodal selective attention task and found no significant correlations, suggesting some difference in uni- and cross-modal selective attention. The results are discussed with respect to the shared nature of resources across modalities.

P6.140 SOUND HELPS TO RESCUE UNAWARE VISUAL INFORMATION TO AWARENESS VIA CROSS-MODAL BOTTOM-UP ATTENTIONAL CAPTURE

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Many studies support bottom-up cross-modal integration resulting in automatic signal enhancement, such as in the pip-and-pop effect. We addressed whether visual information that is suppressed from awareness in binocular rivalry can be 'rescued' to awareness via this kind of bottom-up cross-modal integration. Although several studies have shown cross-modal integration in binocular rivalry, the role of top-down regulation has usually not been discarded. We measured perceptual flips in a binocular rivalry paradigm after uninformative sounds or abrupt visual events on the suppressed or dominant percept. Visual and acoustic events occurred unpredictably and in an uncorrelated fashion, sometimes occurring at the same time. In line with the literature, our results showed that an abrupt uni- or multi-sensory stimulus accelerate the alternation dynamics of binocular rivalry, overall. Interestingly, however, an abrupt visual stimulus on the suppressed eye induced a faster switch when coinciding with a sound than the visual or the auditory events per se. A further analysis of the data showed that this shortened alternations induced by bimodal stimuli did not differ from the prediction of a probability summation model, whereby sound and vision have independent contributions. Thus, we conclude that despite bimodal events result in 'rescue' of visual subliminal stimuli to awareness, this is not a consequence of bottom-up integration. Instead, the results favor the interpretation of independent contributions of bottom-up transient events, both contributing to the alternation in conscious percept.

P6.141 MULTISENSORY TOP-DOWN SETS: EVIDENCE FOR CONTINGENT CROSSMODAL CAPTURE

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Numerous studies that have investigated visual selective attention have demonstrated that a salient but task-irrelevant stimulus can involuntarily capture a participant's attention. Over the years, there has been a lively debate concerning the impact of contingent top-

down control settings on such stimulus-driven attentional capture. In the present research we investigated whether top-down sets would also affect participants' performance in a multisensory task setting. A non-spatial compatibility task was used in which the target and the distractor were always presented sequentially from the same spatial location. We manipulated target-distractor similarity by varying the visual and tactile features of the stimuli. Participants always responded to visual target features (color). The tactile features were incorporated into the participants' top-down set only when the experimental context allowed for the tactile feature to be used in order to discriminate the target from the distractor. Larger compatibility effects after bimodal distractors were observed only when the participants were searching for a bimodal target and tactile information was useful. Taken together, these results provide the first demonstration of non-spatial contingent crossmodal capture.

P6.142 VISUOHAPTIC INTEGRATION IN PERCEPTION OF MÜLLER-LYER FIGURES: A COMPARISON OF RESPONSE METHODS

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Background. Both visual and haptic sensory modalities provide detailed information (Schifferstein & Cleiren, 2004) and sensory integration forms a robust (Ernst & Bulthoff, 2004) and reliable (Ernst & Banks, 2002) representation of stimuli. Geometric illusions (i.e. Müller-Lyer illusion) have been used as a tool to determine commonalities between visual and haptic processing of stimuli (Casla and Blanco, 1999). Purpose. To determine whether visuohaptic integration affects participants' judgment of shaft length in Müller-Lyer figures compared to unimodal responses. Hypothesis. Participants' haptic responses will differ compared to visuohaptic responses for conditions where a true haptic (kinesthetic and tactile) response is not made. Methods. Stimuli consisted of raised fins-in and fins-out Müller-Lyer figures, and no-fins control figures. Participants explored stimuli in visual, haptic, and visuohaptic conditions. Similarly, responses were made through vision, touch, or a combined visuohaptic response. Participants responded through a true haptic method (tracing) and kinesthetic only methods (drawing, comparison, and sliding ruler). Results. As hypothesized, a statistically significant difference was observed between participants' haptic responses and visuohaptic responses for both drawing, $t(16) = -4.34$, $p < .01$, and sliding ruler, $t(16) = 2.08$, $p = .05$, response conditions but not for the tracing response method, $t(16) = -0.13$, $p = .90$. Discussion. The addition of visual information during a haptic response influences judgment of shaft length where only kinesthetic information is involved. Participants' judgments via true haptic response (tracing) were not influenced by the addition of visual information. Methodological implications for future research and commonalities among modalities are discussed.

P6.143 MODALITY-SPECIFIC ATTENTION MODULATES THE VENTRILOQUIST ILLUSION

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To form a coherent percept of the environment the brain integrates sensory signals weighted by their reliabilities (i.e. inverse of variance). A controversial question is to what extent multisensory integration can be modulated by attention. Using dual task paradigm previous research has suggested that the sensory weights in the integration process are independent of modality-specific attention (Helbig & Ernst). Yet, accumulating evidence from EEG and fMRI has demonstrated profound influences of attention on multisensory integration. The current paradigm investigated the role of modality-specific attention on the sensory weights in multisensory integration during spatial localization. Participants were presented with audiovisual stimuli where the auditory and visual positions were independently sampled from the left or right positions. Critically, the audiovisual stimulus was presented in a pre-post cuing paradigm that orthogonally manipulated (i) the modality to be attended indicated by a cue 1 presented prior to the audiovisual (AV) stimulus and (ii) the sensory modality to be reported indicated by a cue 2 presented after the AV stimulus. The attentional pre-cue was valid i.e. congruent with the post-cue in 75% of the trials. Our results demonstrate that the visual signal exerted a stronger weight on the perceived auditory location when it was attended relative to when it was unattended. Likewise, the perceived visual location was more strongly influenced by the true sound location when the sound was attended. These results provide initial evidence that modality-specific attention influences how human observers integrate sensory signals into a coherent percept of the environment.

P6.144 THE RACE FOR FOOD: RESPONSE FACILITATION IN VISUAL-OLFACTORY STIMULATION

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The visual appearance and odor of food constitute the primary sensory information to be evaluated before ingestion. Integration of these inputs into a coherent unitary percept determines food perception and thus food preference and choice. However, the neural underpinnings of these processes and their behavioral implications are still unknown. For a variety of different senses it has been shown that the presentation of redundant target features often leads to improved performance, i.e. higher accuracy and faster response times

(RTs). This redundant signals effect (RSE) can be modulated by stimulus intensity, is usually most pronounced for weak stimuli, and is generally considered a necessary (albeit not sufficient) evidence for neural integration. We designed a paradigm to examine cross-modal interactions in the perception of food-related stimuli to investigate whether these fundamental observations are also valid within the realms of the chemical senses. We presented participants with weak representations of two different food objects, either as purely visual or olfactory stimuli, or as their congruent bimodal combinations. To accommodate for the differential processing speed of both modalities, stimulus onset of the bimodal components was de-synchronized to maximize the perceptual overlap between the unimodal streams. The task was to identify the objects and press a corresponding button as quickly as possible (speeded 2-AFC). Analysis of mean RTs and RT distributions revealed a significant RSE. The findings are consistent with race models, suggesting independent processing of the visual and olfactory stimulus components.

P6.145 CORTICAL ENTRAINMENT TO THE SPEECH ENVELOPE DURING AUDIOVISUAL SPEECH PROCESSING: A CORRELATED AND COMPLEMENTARY MODE PERSPECTIVE

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During conversation, auditory cortical activity is entrained to the temporal envelope of speech (Lalor and Foxe, 2010). This entrainment is insensitive to background noise at certain signal-to-noise ratios (SNRs) where intelligibility has declined (Ding and Simon, 2013). In such adverse hearing conditions, it has been demonstrated that viewing a speakers' articulatory movements can improve the comprehension of auditory speech equivalent to that produced by an increase of up to 15 dB in SNR (Sumby and Pollack, 1954). Recently, Ross et al. (2007) demonstrated that this behavioural enhancement is most pronounced at a certain SNR, beyond that predicted by the principle of inverse effectiveness. However, it remains unclear how the addition of visual speech may influence neural tracking of the acoustic envelope at such an optimal SNR. In this study, we examined the impact of visual speech on envelope tracking for clean speech and speech-in-noise using electroencephalography (EEG). Stimuli consisted of audio-only (A), visual-only (V) and audiovisual (AV) speech. For speech-in-noise, the audio was embedded in spectrally matched white noise at an SNR of −9 dB. Behavioural piloting identified this SNR as being the multisensory 'sweet spot', whereby intelligibility was significantly greater for AV speech compared to A speech. A direct measure of envelope tracking was obtained using the method of stimulus reconstruction (Mesgarani et al., 2009). Here, we present a framework for utilizing this approach to index crossmodal interactions in continuous speech and in doing so, demonstrate that such interactions are more pronounced in sub-optimal hearing conditions.

P6.146 HEARING THROUGH YOUR EYES: THE VISUALLY-EVOKED AUDITORY RESPONSE

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Synaesthesia is typically presented as a rare and exotic pairing of conscious sensations, affecting only about 5% of the population. But here we present a barely-known form of visual-to-auditory synaesthetic correspondence, which seems much more prevalent. In a random sample of 40 neurotypical adults, we measured the ability to match pairs of 'Morse-code' sequences of flashes or tones (following Saenz & Koch, 2008). 15% of participants, who performed significantly better on the visual sequencing task than others, responded 'Yes' when asked whether they heard faint sounds accompanying the flash stimuli. Visual performance was also significantly better in a separate sample of musicians. We next tested whether detection of real auditory signals could be masked by visually-evoked illusory sounds (Lovelace et al, 2003). In support of this, participants with better visual relative to auditory sequencing performance did have poorer auditory detection thresholds in the presence of uncorrelated visual flashes, whether they were aware of corollary sounds or not. Further tests based on the Colavita effect discounted explanations based on attentional bias towards visual versus auditory modalities. The surprising prevalence of this visually-evoked auditory response (V-EAR) may arise due to the greater natural correlation between visual and auditory stimuli, in contrast with the more exotic associations typified by synaesthesia. But whether subjectively experienced or not the visually-evoked auditory response has an objectively measurable effect on audition. Our results therefore suggest that learned correspondences between strongly correlated modalities may provide a precursor for synaesthetic abilities, and may sometimes be sufficient for full-blown synaesthesia.

P6.147 UNCERTAINTY IN NAVIGATION: OPTIMAL INTEGRATION OF LANDMARK AND PROPRIOCEPTIVE INFORMATION?

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Spatial navigation involves the ability to memorize the location of a goal often using sensory information from multiple sources. Information about movement and posture of the body originates from proprioception, kinaesthetic and vestibular senses. External reference points, such as landmarks or beacons, however, convey information about the spatial position of the individual in given surroundings. What homing strategies are used when humans are uncertain about the information available? We first tested each single

modality involved in our navigation paradigm alone: (a) path integration and the perception of self-motion. (b) The participants' performance in an audio landmark homing paradigm using small loudspeakers placed on the floor in a large sporting hall. We systematically manipulated the spatial layout of landmarks surrounding the goal without the participants' notice. Combining (a) and (b) we then studied to which extent and how sensory information is combined during navigation. Each modality alone is imprecise and ambiguous. While the representation of motion direction is strongly biased, the audio navigation performance depends mainly on the spatial layout and sound of the landmarks and their respective ambiguity. Whereas single modalities are too noisy for accurate and precise navigation, we find that participants successfully integrate the different types of information. Thus, they seem to integrate all available sources to find their goal using highly pragmatic strategies for navigation.

P6.148 OLFACTORY RECEPTORS IN THE EYE

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Multisensory integration of smell and vision is well documented. Blind people demonstrate an increased olfactory sensitivity compared to sighted controls. Under normal viewing conditions, semantically congruent olfactory and visual stimuli can decrease detection thresholds, affecting adaptation rates and intensity judgements. These behavioural advantages appear to be mediated by activity in the hippocampus in humans, but there are also reports of centrifugal projections from the olfactory bulb to the retina in the Zebrafish. Here, we investigated the possibility that the natural association between olfaction and vision can be partially explained by the presence and distribution of an olfactory G-protein (Gαolf) in the eye of mammals. Using immunohistochemistry and confocal microscopy, we found that Gαolf was differentially expressed in the retina of mice, treeshrews, and monkeys. More specifically, high expression of Gαolf was found in all layers of the mouse retina. In the tree shrew retina, moderate expression of Gαolf was found throughout the retinal layers. In the monkey retina, Gαolf immunoreactivity was exclusively localized in the inner nuclear layer and ganglion cell layer. This represents the first finding that an olfactory-type G-protein is present in the eye of mammals. Additionally, the expression pattern across the species tested suggests that olfactory receptors in the eye are more important for less evolved animals (who rely more on smell) than for primates with a highly evolved visual sense. Projections from the olfactory bulb to the retina might underpin the cross-modal association between smell and vision.

P6.149 BIASED MEMORY DEPENDING ON STATISTICAL RELATIONSHIP IN CROSS-MODAL EXPERIENCES

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In the external world, we are exposed to a constant flow of multisensory information including visual and haptic signals. The signals often covary, e.g., size and weight. The learning to the covariation could be important in cross-modal perception or behavior. However, we learn different sets of signals from different events. How do we integrate their events and organize our knowledge about the covariation? One possibility is that we summarize cross-modal events in statistical manner. Grasping functional relationship between signals would help to form compact representation of the multisensory world and predict inexperienced combination of signals. We investigated the idea through a visuo-haptic memory task. Participants experienced sequential presentation of seven square patches with different luminance on a screen and forces with different stiffnesses on a haptic device, followed by a test stimulus. They were asked to judge whether the test stimulus was identical to either item in the former sequence. In half of the trials, the visual and haptic signals in a sequence were highly correlated, though it was the task-irrelevant property. In the remaining half of the trials, they were not correlated. Participants biased their responses depending on the functional relationship between signals in the sequence. Participants found it harder to reject the fake test stimulus when its visual and haptic signal values are closed to the relationship embedded in the sequence. Results suggest that we summarize the statistical relationship from few numbers of events and utilize it for the cognitive judgments.

P6.150 AUDIOVISUAL DISTANCE PERCEPTION: SENSORY WEIGHTS AND WINDOWS OF INTEGRATION

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Audiovisual integration in distance perception is an uninvestigated aspect of multisensory integration. This research was conducted using natural scenes: both audio and video of a person playing a chord on an organ were recorded in a room at multiple distances. The audio and video stimuli were separated and matched randomly, and they were rendered using Oculus Rift and headphones with DirAC sound reproduction. For each di↵erent combination of audiovisual stimuli it was asked to the listener to judge the perceived visual and auditory distance. It was proved that the impact of auditory stimuli over visual distance judgement is negligible, while there is a relevant impact of visual stimuli on auditory distance evaluation. The answers for each pair of audiovisual distances were modeled as a linear

combination of the unimodal stimuli, with the constraint for the weights to sum up to one and to fit the average responses over the stimuli pair. The weigths were grouped by auditory distance, and the results showed a common pattern. The visual weight was found greater than the auditory one for the pairs when visual stimuli was just further than the auditory one, and auditory weight was found predominant when the stimuli were well separated from each other in distance. It was also investigated how far must the audio and visual stimuli be in order to be integrated in the same event, i.e. perceived as the same coherent event. This led to the formulation of the window of integration as a function of distance and distance between stimuli.

P6.151 ATTENTION INFLUENCES THE VENTILOQUIST ILLUSION

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Audio-visual integration has been assumed to be an early automatic process and as such attention has been ruled out as playing a role in the best known of multisensory illusions: the ventriloquist illusion. While there is ample evidence for the early integration of audio-visual information in many multisensory phenomena, recent research has shown that attention can play role. We reasoned that a cue that drew the attention of an observer to the source location of the auditory stimulus would weaken the displacement of the sound source toward the visual stimulus. The ventriloquist illusion was induced by short videos of a female speaking with the sound source displaced 7.4o t either the left of right. Attention was drawn to the location of sound source by short bursts of white noise just prior to the onset of the audio-visual stimulus. The presence of the attentional cue significantly improved sensitivity to the source location of the audio stimulus (i.e. weakened the ventriloquist illusion). Critically there was no change in the participant's response criteria. We speculate that in making location judgements attention is focused on the visual stimulus because of the greater spatial reliability of vision, which gives rise the ventriloquist illusion. The auditory location cue weakens the illusion because attention is tethered to the location of the sound source for a short time after the start of the audio-visual stimulus.

POSTER SESSION 7: NEURAL SUBSTRATES

P7.152 IN SEARCH OF NEURAL CORRELATES OF AUDIO-VISUAL BINDING

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The understanding of speech in noisy settings is greatly enhanced by perceptually binding a talker's voice with his or her face as it moves. We recently tested the extent to which temporal coherence alone, free of linguistic effects, is responsible for this binding. By using synthetic stimuli to control basic coherence between dynamic features of ongoing auditory and visual stimuli, we found enhanced perception of auditory features, even though the visual stimulus provided no information. However, the neural basis underlying this temporal coherence-based audio-visual binding is not known. Here we recorded magneto- and electroencephalography using a similar behavioral paradigm. We presented two auditory tone complexes whose amplitudes were modulated by independent 7 Hz low-pass noise envelopes, and a visual dartboard-like pattern whose radius changed with similar temporal dynamics. We manipulated audio-visual binding by varying the temporal coherence between the auditory amplitudes and visual radius, with the radius matching either the auditory target, the auditory masker, or neither. Subjects were asked to monitor the target auditory stimulus for brief frequency modulation events and the visual stimulus for brief color changes, and press a response button when those happened simultaneously We analyzed two types of neural responses: event-related responses time-locked to stimulus events, and steady-state responses at frequencies that were ""tagged"" in the stimulus streams. The results of the study contribute to our understanding of the cortical networks involved in audio-visual binding and multisensory processing.

P7.153 WIDESPREAD INFLUENCE OF EYE DOMINANCE ON VISUO-MOTOR TRANSFORMATIONS: EVIDENCES FROM BEHAVIORAL AND ELECTROPHYSIOLOGICAL STUDIES

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Our dominant eye is the one we unconsciously choose when performing a monocular task. Several studies revealed that the stimulation of this dominant eye activates a larger cerebral network than the stimulation of the non-dominant eye. Nevertheless, the consequences of this lateralization of the visual system in sensorimotor tasks has been poorly explored. Here we report a set of three experimentations demonstrating that eye dominance influences the visuo-motor transformations at different stages. Firstly, by selecting participants according to their dominant eye, and varying the side of the stimulated visual hemifield in a simple reaction time task (i.e. Poffenberger paradigm), we showed that, in right-handers, manual reaction times were shorter for targets presented in the contralateral hemifield than

in the ipsilateral hemifield with respect to the dominant eye. Secondly, we observed that, during vertical saccadic eye movements, the presentation of a distractor in the contralateral hemifield causes a larger deviation of the saccade trajectory compared to the presentation of a distractor in the ipsilateral hemifield. Finally, we also focused on a fundamental process of the human visuo-motor transformations: the interhemispheric communication. We used electroencephalographic recordings to accurately evaluate the time required to transfer the visual information from one hemisphere to the other. Results showed that this interhemispheric transfer time strictly depends on the eye dominance. Overall, our findings demonstrate that eye dominance has a widespread influence in visuo-motor processes and indicate that this human brain lateralization has been overlooked up to now

P7.154 NEURAL MECHANISMS OF RELIABILITY-BASED CUE WEIGHTING DURING AUDIOVISUAL INTEGRATION

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We investigate the neural mechanisms underlying audio-visual cue integration. To this end, we combine a rate discrimination task with EEG-based neuroimaging, and exploit Bayesian cue integration models to understand patterns of behavioural cue integration and the underlying neural mechanisms. We use auditory and visual flutter stimuli that vary in rate (8 to 15 Hz), congruency, and reliability (manipulated by adjusting the signal-to-noise ratios of the visual stimuli), allowing us to estimate subjects' psychometric curves and calculate the predicted and observed sensory weights. We expected that psychometric weights should shift from vision to hearing when the visual stimulus becomes less reliable. Indeed, behavioural data from six participants confirmed this, with PSEs shifted towards the more reliable auditory cue for all participants. We then map the weighted average integration model onto oscillatory activity extracted from single trial EEG data to identify areas where the activity elicited by audiovisual stimuli is modulated by the reliability of the visual information. To do this, for each subject we created a general linear model (GLM) contrasting Audio-visual and Visual conditions, and weighted this difference using the observed sensory weights from the behavioural data. The resulting statistical maps from the GLM were then averaged across subjects. This revealed increased alpha and beta activity from 500ms post stimulus onset over posterior and central electrodes, and increased gamma activity over temporal/parietal and frontal electrodes at stimulus onset. These results point towards a role of local gamma band activity and the involvement of beta-band feedback in cue integration.

P7.155 TOWARD AN OBJECTIVE MEASURE OF AUDIO-VISUAL INTEGRATION USING STEADY-STATE RESPONSES RECORDED WITH MAGNETOENCEPHALOGRAPHY

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The auditory modality typically provides the most salient information in order to sample the frequency (or beat) of events. For example, it has been repetitively demonstrated that a visual flicker is perceived to follow an auditory flutter that is presented concurrently but at a different frequency. However, the intrinsic neuronal mechanisms underlying such multisensory integration remain largely unknown. We addressed this question by recording audio-visual steady-state responses (SSR) using Magnetoencephalography (MEG) while participants experienced a multisensory illusion in which a visual flicker and an auditory flutter presented at different frequencies were sometimes perceived as synchronous. We observed that the perceptual binding of multisensory information was associated with changes in the steady-state responses elicited by each modality. Moreover, multisensory integration in the "illusory" trials was associated with a modulation in spontaneous oscillatory activity. Our results represent an important step for our understanding of how auditory and visual information are combined to build a coherent representation of an event frequency. Moreover, our study highlights the potential of steady-state responses for identifying objective measures of neural activity associated with multisensory integration.

P7.156 NEURAL CORRELATES OF PROCESSING OF PATH DIRECTION DURING WALKING USING ECHOLOCATION

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It is by now well established that people can use echolocation to interact with the environment. Recent brain imaging studies have demonstrated that skilled blind echolocators recruit primary visual areas when they judge shape, identity or location of surfaces using echoes. In this study we examined the neural activity underlying the processing of path direction during walking. Brain activity was measured using fMRI in 3 blind echolocation experts, and 3 blind and 3 sighted novices. During scanning, participants listened to binaural recordings that had been made in a naturalistic indoor and outdoor setting prior to scanning while blind experts had echolocated during walking along a corridor which could continue to the left, right, or straight ahead. Participants also listened to control sounds that contained ambient sounds and clicks, but no echoes. They indicated via button press if the corridor continued to the left, right, or straight ahead, or if they were listening to a control sound. All participants successfully dissociated echo from no-echo sounds, however, echolocation experts performed better at direction detection. We found brain activations associated with processing of path

direction (contrast: echo vs. no-echo) in superior parietal lobe (SPL) and inferior frontal cortex in each group. However, SPL activation was more pronounced in blind participants. In sighted novices, additional activation occurred in inferior parietal lobe (IPL) and middle and superior frontal areas. Our results are consistent with the idea that blind participants automatically assign directional meaning to echoes, while sighted participants apply more conscious, high-level spatial processes.

P7.157 SEEING OUR OWN VOICE: AN ELECTROPHYSIOLOGICAL STUDY OF AUDIOVISUAL SPEECH INTEGRATION DURING SELF PERCEPTION

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Recent studies suggest that better recognition of one's actions may result from the integration of sensory inputs with our own sensory-motor knowledge. However, whether hearing our voice and seeing our articulatory gestures facilitate audiovisual speech integration is still debated. The present EEG study examined the impact of self-knowledge during the perception of auditory, visual and audiovisual syllables that were previously recorded by a participant or a speaker he/she had never met. Audiovisual interactions were estimated on eighteen participants by comparing the EEG responses to the multisensory stimuli (AV) to the combination of responses to the stimuli presented in isolation (A+V). An amplitude decrease of early P2 auditory evoked potentials was observed during AV compared to A+V. Moreover, shorter latencies of N1 auditory evoked potentials were also observed for self-related visual stimuli compared to those of an unknown speaker. In line with previous EEG studies on multimodal speech perception, our results point to the existence of early integration mechanisms of auditory and visual speech information. Crucially, they also provide evidence for a processing advantage when the perceptual situation involves our own speech productions. Viewing our own utterances leads to a temporal facilitation of the integration of auditory and visual speech signals.

P7.158 THE NEURAL BASIS OF CULTURAL DIFFERENCES IN EMOTION PERCEPTION FROM FACIAL AND VOCAL EXPRESSIONS

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Information from faces and voices plays an important role in social communication. Tanaka et al. (2010) found that Dutch participants are more attuned than Japanese participants to facial processing in the multisensory perception of emotion by behavioral study. In the current study, we examined the neural basis of these cultural differences by using fMRI. In the experiment, Japanese and Dutch participants observed Japanese and Dutch speakers' utterances with happy or angry emotions and judged the emotion. Stimuli consisted of the unisensory (i.e., face or voice only) and mulitisensory (i.e., both face and voice) stimuli. The multisensory stimuli were divided into congruent stimuli (i.e., expressing the same emotion by face and voice) and incongruent stimuli (i.e., expressing different emotions by face and voice). Participants were given two tasks: the face task and the voice task. In the face task session, participants were presented with the multisensory or face stimuli and were instructed to categorize the emotion of the faces as happy or angry while ignoring the voice. In the voice task session, participants were presented with the multisensory or voice stimuli and were instructed to categorize the emotion of the voices as happy or angry while ignoring the face. Participants responded by pressing one of two buttons (happy or angry). Behavioral data on the multisensory stimuli showed that Dutch participants are more attuned than Japanese participants to face. Based on the imaging data, the neural basis of this cultural difference (e.g., fusiform face area) will be presented.

P7.159 IS SENSORIMOTOR COUPLING A SEQUENCE OF MODULAR ACTIVATIONS OR A UNIFIED PROCESS?

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This EEG study investigates whether sensorimotor coupling in the human brain is organized into separate modules processed in sequence or whether functional modules are involved in the complete processing period. For that we operationalize modules with ICA components and investigate these in a reaction time task with multimodal stimuli. A stimulus is a colored text, which appears on a monitor simultaneously with an auditory word in a headset. Participants categorize each stimulus into True or False in accordance with a given rule by pressing button 1 (TRUE) or button 2 (FALSE). 12 subjects took part in this study. EEG-data analysis was done based on activity of ICs obtained by independent component analysis (ICA). We found bi-modal ICs, which have both, stimulus aligned as well as button press aligned ERP responses. These bi-modal ICs mostly belong to left parietal and deep central brain areas. This observation is not dependent on the number of channels or ICA components recorded. The study was done with 128, 64 channel EEG

systems, as well as 32 channels subsample of EEG data. The number of bi-modal ICs was constant among the systems. Our results demonstrate that in sensorimotor processes some independent components, equated to modules, are active in the whole interval from stimulus onset to motor response. We assume that these bi-modal ICs represent certain brain areas, which serve as functional modules involved in a sensorimotor coupling and bridge the whole arch from stimulation to motor-output.

P7.160 WHITE MATTER CONNECTIONS OF THE VESTIBULAR AND VISUAL-VESTIBULAR INSULAR CORTEX

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A key area of the cortical vestibular network is the parieto-insular vestibular cortex (PIVC) located in the posterior insula. We recently showed that the parieto-insular cortex (PIC), located posterior to PIVC, responds to visual and vestibular cues about self-motion. We investigated the structural connectivity of PIVC and PIC using probabilistic fiber tracking based on diffusion-weighted imaging (DWI) of 14 healthy right-handed people. PIVC and PIC were identified in each subject by functional magnetic resonance imaging (fMRI). Bi-thermal caloric stimulation was used to identify PIVC whereas PIC was defined by a visual motion localizer. These regions of interest served as seeds for probabilistic fiber tracking. Terminations of tracks for each seed were mapped upon the cortical surface of a standard brain. White matter connections of PIVC and PIC showed overlapping track terminations to each other, the insular/lateral sulcus, superior temporal cortex, and inferior frontal gyrus. We compared the connectivity profiles of PIVC and PIC by analyzing the differences of track terminations across the whole cortical surface. This analysis showed significant differences in the connectivity fingerprint of the two regions. PIVC showed connections primarily to the posterior parietal cortex, the frontal operculum, and the Heschl's gyrus. By contrast, more pronounced PIC track terminations were found in the temporo-parietal junction, superior temporal sulcus and the inferior frontal cortex. Moreover, more PIVC tracks were observed in the splenium. Our results suggest that although PIVC and PIC both seem to be relevant for vestibular-visual interactions, these two regions show distinct profiles of white matter connectivity.

P7.161 CONNECTIONS BETWEEN PRIMARY AUDITORY AND PRIMARY VISUAL CORTICES: DIFFUSION MRI EVIDENCE

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Multisensory interactions rely on anatomical interconnectivity at multiple levels of sensory processing hierarchies. In addition to well-known networks involving subcortical convergence zones or higher-order association cortices, direct pathways between early sensory cortices are thought to underlie some aspects of multisensory processing. Previously, anatomical tracer studies in non-human primates revealed the presence of a direct pathway between auditory cortex and primary visual cortex. However, MRI-based computational tractography has yet to provide statistically rigorous evidence for a human homologue of this pathway. Because computational tractography provides only indirect evidence for white matter pathways in the brain, careful validation against primate tracer results can be critical for distinguishing valid from spurious inferences about connectivity. In order to identify the hypothesized pathway in humans and compare its features to known features of the pathway found in macaques, we performed probabilistic tractography on high angular resolution diffusion MRI data from the Human Connectome Project. Consistent with tracer studies, we found that streamlines seeded from Heschl's gyrus terminated predominantly on the dorsal lip of the calcarine sulcus, with very few terminating ventrally. These results suggest that computational neuroanatomy techniques can indeed identify a pathway in the human brain with specific features homologous to those found in non-human primates. This finding provides further evidence for anatomical connectivity between primary auditory cortex and the portion of primary visual cortex representing the lower visual field in the human brain. Future research will use functional connectivity measures and recently developed tract-based inferential methods to further validate these results.

P7.162 MULTISENSORY INTEGRATION USING PERITHRESHOLD DYNAMIC STIMULI

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Weak sensory information from multiple channels act synergistically by combining their independent estimates of the same event to provide a better analyses of its features. However, even though many sensory stimuli we encounter are noisy, most studies to date have used clearly-perceivable stimuli wherein the added benefit of integration is limited. Using fMRI (n=29), we assessed the neural and behavioral mechanisms of sensory integration of both perithreshold (Weak) and suprathreshold (Clear) dynamic visual and auditory stimuli (2s long video and audio clips of natural objects). Prior to the experiment, individualized unisensory identification threshold levels were assessed for each stimulus within the scanner to a 70% accuracy level. We subsequently presented congruent Weak and Clear

uni- and bimodal stimuli, masking of each unisensory stimulus was adjusted to a 70% identification accuracy throughout. After each trial, participants identified the presented object among five choices (5-forced-choice-task); a task that demonstrated clear multisensory integration effects (violation of the Race Model) in a separate behavioral experiment. According to a Drift Diffusion Model, Weak bimodal stimuli were more robustly (faster and more accurately) integrated compared to Clear bimodal stimuli. Conversely, Weak bimodal stimuli, compared to Clear stimuli, also evoked significantly larger activity (bilaterally) within a network comprising the intraparietal sulcus, anterior insula, inferior frontal gyrus, and supplementary motor cortex. Taken together, these results provide further evidence that using Weak sensory stimuli provides a link between previous findings of reversed effectiveness on a single neuron level to levels of both the human brain and overt behavior.

P7.163 SALIENT SOUNDS ELICIT LATERALIZED DECREASES IN THE OCCIPITAL ALPHA RHYTHM THAT PREDICT VISUAL DISCRIMINATION ACCURACY

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Recent studies have shown that sudden, intrusive sounds activate the visual cortex automatically. In a series of experiments, lateralized sounds that were completely task-irrelevant elicited a positive deflection over contralateral occipital cortex in the event-related potential (ERP; McDonald et al. (2013)). This ERP component, termed the ACOP (auditory-evoked contralateral occipital positivity), predicted improved pattern discrimination of a subsequent visual target (Feng et al., 2014), indicating its functional significance for cross-modal interactions. The present study investigated whether such spatially non-informative sounds also influence the dynamics of oscillatory EEG activity over visual cortex. On each trial a sound was presented at the left or right side of a video monitor, participants were required to discriminate a subsequent visual target presented unpredictably to the same or the opposite side. These non-predictive sounds induced a relative decrease in alpha-band power contralateral to the sound's location. The magnitude of this contralateral alpha-band desychronization showed a strong correlation with the amplitude of the ACOP, suggesting a close relation between the two measures. Like the ACOP, the contralateral decrease in alpha-band power was predictive of target discrimination accuracy on a trial by trial basis, with greater contralateral alpha-band power decreases prior to correct than incorrect discriminations of visual targets that were co-localized with the preceding sound. These results suggest that decreases in contralateral occipital alpha-band power are closely linked to the ACOP and further indicate that changes in the occipital alpha rhythm are intimately involved in the involuntary orienting of attention to the location of a sound.

P7.164 ACTIVATION OF VISUAL CORTEX BY SALIENT SOUNDS: NOT AUTOMATIC

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Upon hearing a sudden sound, we get a feeling that information processing in its location becomes 'sharpened', in audition as well as other senses. What about more predictable sounds? While the multi-sensory nature of real-world environments typically facilitates information processing, the automaticity of these cross-modal influences and their brain underpinnings remains poorly understood. Automaticity has recently been invoked to explain the activation of visual cortices by laterally-presented sounds: These modulations were observed despite sounds being task-irrelevant and spatially uninformative about subsequent targets. An auditory-evoked contralateral occipital positivity (ACOP) at ~250ms post-sound onset has been postulated as the event-related potential (ERP) correlate of this "automatic" cross-modal effect. However, the spatial dimension of the stimuli was relevant in all prior studies where the ACOP was observed. To address this issue, we manipulated the implicit predictability of the spatial location of lateralized sounds within a passive auditory paradigm (that rendered sounds completely irrelevant). 128-channel ERP data from healthy participants were analyzed within an electrical neuroimaging framework to test the automaticity of the ACOP in contexts where behaviour indices are necessarily unavailable. The timing, topography, and localization were identical to previous characterizations of the ACOP. However, the presence of sound-elicited cross-modal activations of visual cortices were critically dependent on whether the sound location was (un)predictable. Our findings are the first direct evidence against the current consensus that this cross-modal process is automatic. Critically, they highlight the importance of context-based mechanisms, and of their interactions with task-relevance mechanisms, in controlling information processing across senses.

P7.165 CORTICAL RESPONSES TO CONGRUENT AND INCONGRUENT MULTISENSORY CUES FOR OBJECTS ON A COLLISION PATH WITH THE OBSERVER

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Evidence points to multisensory integration of a range of cues when estimating the speed of approaching objects. Optical looming and depth cues are normally congruent when viewing motion in natural scenes. We explored the cortical responses to visual collision events that were presented via stimuli that changed in size (looming) or stereo-depth (binocular motion), or both. In particular we examined the differences in cortical response when the looming and binocular cues were congruent or incongruent in the collision information they provided. A stereoscopic goggle system was used within the fMRI environment and allowed us to present looming and disparity cues in isolation, or in congruent or incongruent combinations. Following univariate analysis it was found that incongruent looming and binocular motion cues elicited additional activation in cortical areas known to process error and locate objects in spatio-topic coordinates. Visual regions which showed high predictor values using multivariate pattern analysis concurred with research which has highlighted areas V1 - V3 and V6 in disparity processing. Results are discussed in terms of visual, cognitive and motor responses to seeing incongruent cues.

P7.166 EXPLORING VISUO-TACTILE CROSSMODAL ATTENTION USING THE FREQUENCY-TAGGING OF STEADY-STATE EVOKED POTENTIALS.

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Covertly directing ones' attention to the location of a stimulus of one sensory modality can affect the processing of the stimulus of another modality when presented at the same location. Here, we explored these mechanisms using steady-state evoked potentials, suggested to reflect (at least partially) brain processing in primary sensory cortices. Using light emitting diodes, two 16s sustained trains of flickering visual stimulation were concomitantly presented in either side of space. At the same time a train of vibrotactile stimulation was applied on the participant's hand. In different blocks, the hand was positioned close to either the left or the right diode. Three different frequencies of stimulation were chosen to tag the specific EEG responses to the three different stimuli (visual left, visual right, tactile). Participants were asked to report occasional interruptions in the three streams of stimulation. The preliminary results show a tendency for a modulation of the visual steady-state evoked potentials according to the position of the stimulated hand: amplitude was lower when the stimulated hand was placed close to the visual stimulus. This suggests that body posture influences visual processing in primary visual cortical areas.

P7.167 MULTISENSORY EFFECTS IN SUPERIOR COLLICULUS AS EMERGENT PROPERTY OF THE CORTICAL DECISION MAKING CIRCUITRY: A COMPUTATIONAL STUDY

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For constructing the target for gaze-shift, namely in superior colliculus, when visual and auditory signals are present, the subject needs to decide between three scenarios: 1) The same source for signals. 2) Separate sources and target chosen at the location of the visual stimulus. 3) Separate sources and target chosen at the location of the auditory stimulus. Evidence suggests this decision is made based on the spatial congruency and temporal simultaneity of the two stimuli as well as their respective saliencies. Bayesian framework has been previously used for addressing this problem (Rowland et.al 2007). We use the neural engineering framework (Eliasmith et.al 2012). We propose that the three mentioned scenarios are manifested in three plans which are represented in the laminar structure of frontal eye fields along with their corresponding saliencies. The saliencies of the plans are computed from the spatiotemporal similarity of the stimuli and their corresponding reliabilities. A decision variable is constructed based on the saliency of the plans. The decision on which plan to be executed is made through a threshold function of the decision variable. The decision is implemented through interaction with the basal ganglia (direct pathway) and selective disinhibition of the executive neurons in FEF. The winning plan is sent to the intermediate layer of superior culliculus (SC). The reported multisensory neural effects, like spatial principle, temporal principle and inverse effectiveness, can be seen in this sensorimotor map. The gaze-shift command is ultimately sent 'down' to brainstem and spinal cord to be implemented.

P7.168 ALTERED VISUAL FEEDBACK MODULATES CORTICAL EXCITABILITY IN A MIRROR-BOX-LIKE PARADIGM

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Watching self-generated unilateral hand movements reflected in a mirror, oriented along the mid-sagittal plane, enhances the excitability of the primary motor cortex (M1) ipsilateral to the moving hand of the observer. Mechanisms detecting sensory-motor conflicts generated by the mirror reflection of such movements might mediate this effect; if so, cortical excitability should be modulated by an increased sensory-motor conflict. To this aim, we explored the modulatory effects of an altered visual feedback on M1 excitability in a mirror-box-like paradigm, by increasing or decreasing the speed of the observed movement. Fifteen healthy subjects performed

movements with their left index finger while watching a video of a hand superimposed to their right static hand, which was hidden behind the screen. The observed hand executed the same movement of the observer's one, but at slower, same, or faster paces. Motor evoked potentials (MEPs) by Transcranial Magnetic Stimulation were measured from the first dorsal interosseus (FDI) and the abductor digiti minimi (ADM) of the participant's hidden resting hand. The excitability of the M1 ipsilateral to the moving hand was systematically modulated by the speed of the observed hand movement: the slower the observed movement, the greater the MEP amplitude from both muscles. This evidence shows that the magnitude of the visual-motor conflicts can be used to adjust the activity of the observer's motor system. Hence, an appropriate alteration of the visual feedback, here the reduction of the movement speed, may be useful to increase its modulatory effect on motor cortical excitability.

P7.169 CROSSMODAL EFFECTS ON LOCATION SPECIFIC REPETITION SUPPRESSION OF EEG RESPONSES TO SOUNDS

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Space is a dimension shared by all modalities, but at what stage spatial encoding is affected by crossmodal integration is not clear. Previous studies found attenuation of the N1-P2 auditory evoked response following repetition of sounds from the same location. We asked whether this is modulated by audio-visual interaction, and whether it reflects quantitative or qualitative differences in the response. We presented pairs of sounds in free field: the test sound was presented from a fixed lateral location. The preceding adapter sound was presented from the same location or from a more medial location, and was accompanied by a simultaneous flash displayed orthogonally from one of the two locations. Behaviorally, sound-flash incongruence reduced accuracy in a same-different location discrimination task (the ventriloquism effect). The N1, P2 responses to the test sound were attenuated, and P2 attenuation was stronger when adapter sound was at the same rather than different location as the test sound (location-specific adaptation). Importantly, spatially incongruent flashes reduced the location-specificity effect, indicating cross-modal influence on auditory spatial encoding. Further analyses of the corresponding topographies revealed not only differences in global field power, but responses to test stimuli also differed topographically depending on adapter sound location. This difference was more pronounced in the sound-flash congruent than incongruent condition. These findings suggest that location dependent adaptation affects source configuration, which may be further influenced by crossmodal effects.

P7.170 ALTERNATIVES IN SENSORY INTEGRATION DURING NREM SLEEP INVESTIGATED BY MEANS OF HD-EEG

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Sensory stimulation during NREM sleep elicits the K-complex, a triphasic response comprising a sensory-modality independent component (N550) associated to a large-scale cortical hyperpolarization in frontal areas. It has been suggested that this component quenches stimuli integration and preserves sleep/unconsciousness.The fact that only a portion of stimuli evokes K-complex was traditionally explained as a consequence of the thalamic gate closure, but recently we have shown that stimuli reach sensory cortices also in the case they not evoke the K-complex. In fact, stimuli during sleep evoke an early cortical component (P200) travelling to frontal areas irrespectively of whether they evoke or not evoke the K-complex. However, this component shows amplitude increase with travelling only when the stimulus evokes the K-complex. Herein we report results about how brain electrophysiological status before sensory stimulation affects the generation of K-complex. We characterize the status of thalamo-cortical entrainment before each stimulation by studying the EEG power in the sigma band and the related inter-regions synchronization estimated in the 1s baseline segment before each stimulation. We found that baseline epochs preceding the occurrence of a K-complex showed larger values of average sigma power and of its corresponding inter-regions synchronization compared to the baseline epochs preceding the stimuli that did not evoke the K-complex. Taken together, these results show that during NREM sleep the thalamo-cortical system oscillates between an integrated and a fragmented status. P200 recruitment during travelling and N550 hyperpolarization mechanisms seem to intervene for preserving sleep/unconsciousness only during the brain integrated status.

P7.171 INDIVIDUAL DIFFERENCES IN PERIPERSONAL SPACE DERIVE FROM INTER-TRIAL VARIABILITY OF BOLD RESPONSE.

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We live in a dynamic environment, constantly approached by objects that we might have to either avoid or act upon. A multisensory and sensorimotor interface, the peripersonal space (PPS), mediates every physical interaction between our body and the environment. Behavioural investigations show the extension of PPS is extremely variable across individuals. However, evidence is still lacking on elucidating the neural underpinning of these large individual differences. We used functional magnetic resonance imaging to provide evidence that inter-trial variability (ITV), rather than trial-averaged amplitude, of BOLD responses in brain regions encoding PPS, predicts individual PPS extension. To capture individual PPS boundaries, we used approaching auditory stimuli. Specifically for the premotor cortex, we found ITV of BOLD signal responses to far, rather than near, stimuli shapes individual PPS boundaries. Our results also provide the first empirical support to the relevance of regional ITV for human behaviour and its variance across individuals.

P7.172 DIGITIZING THE ELECTROPHYSIOLOGICAL N1 AND P2 TO REVEAL GENERAL EFFECTS OF AUDIOVISUAL SPEECH INTEGRATION

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Electrophysiological measures are widely used to reveal early effects of audiovisual (AV) speech integration, as for example demonstrated by studies showing that lip-read speech modulates the amplitude and latency of the auditory negative N1 and positive P2 peaks (that occur at ~100 ms and ~200 ms respectively). However, variability in analyses protocols is considerable and N1 and P2 effects are not always reported. Some have analyzed mean peak amplitudes and latencies (e.g., Gilbert, Lansing, & Garnsey, 2012), whereas others focus on relative differences between conditions (e.g., Stekelenburg & Vroomen, 2007), peak-to-peak amplitudes (Pilling, 2009), or average EEG activity in certain time-windows (e.g., Baart & Samuel, submitted). To reveal general effects of AV integration at the N1 and P2 that are independent of statistical protocols and choices made by the authors, N1 and P2 values were estimated from published ERP plots, using the EasyNData digitization tool (see also Davidson, Caffarra, Molinaro, & Carreiras, submitted). Only papers that assessed AV integration in AV congruent speech were included, and analyses on the peak estimates (representing averages of > 260 participants in total) revealed that lip-read induced amplitude suppression at the N1 is more stable than at the P2, whereas latency effects were robust and alike for both peaks.

P7.173 EXTRACTION OF REAL OBJECT AND SELF MOTION INFORMATION DURING NATURAL VISION IN THE HUMAN DORSAL STREAM

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Detection of self- and object-motion is crucial for navigation and for sensory-motor interactions with objects. Neurophysiological studies in primates have suggested that the medial occipito-parietal pathway, passing through V6, is preferentially used for self-motion detection while a lateral occipito-temporal-parietal pathway, passing through MT+, is responsible for object-motion analysis (e.g., Rosa & Tweedale 2001; Rizzolatti & Matelli, 2003). The present study aimed to verify whether such a functional specialization also exists within the human dorsal visual stream. In an event-related fMRI study fourteen healthy volunteers watched at movies from a wide-field virtual reality environment simulating a train moving on a railway in five different conditions: (1) object-motion (the subject is still, observing the train moving in front of him); (2) self-motion (the subject is virtually sitting on the train); (3) joint motion (the subject virtually flies over the moving train with the same trajectory and speed as the train); (4) disjoint motion (the subject virtually flies over the moving train but in different trajectories/speeds); (5) static frames (sets of frames randomly extracted from previous movies not eliciting a motion sensation). While some medial (e.g., CSv) and lateral (e.g., MT+) motion regions were preferentially activated for self and object motion, respectively, other regions (e.g., V6) showed a preference for more complex conditions where both object and self motion are present. These visual areas are likely involved in “subtracting out” self-motion signals across the whole visual field for the purpose of flow parsing, i.e., separating object motion from self-motion (Warren & Rushton, 2009).

P7.174 DIFFERENT PRE-STIMULUS BRAIN ACTIVITY IN VISUAL AND AUDITORY DISCRIMINATION TASKS

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Post-stimulus brain activity to visual and auditory stimuli has been widely studied with EEG; pre-stimulus activity was much less investigated. In visual tasks, pre-stimulus slow rising negativity was found not only in premotor areas (the BP component), but also in prefrontal cortex (PFC), and was associated to proactive inhibitory cognitive control. PFC activity was not investigated in the same tasks in auditory modality. The aim of the study was to compare the preparation phase in both modalities. EEG was recorded in ten

participants during passive perception, simple (SRT) and discriminative (DRT) response tasks. The task was to press a key ASAP in SRT to all stimuli, in DRT only to targets (50% of the trials). Response times were comparable for visual (471±88 and 222±37 in SRT and DRT, respectively) and auditory (501±137 and 215±57 in SRT and DRT) modalities; DRT accuracies were comparable (82% and 85%). Event-related potentials were segmented and averaged in 2-s epochs based on stimulus-onset (-1100/+900 ms). For the visual modality, PFC negativity was observed in DRT only. Moreover, the BP component was recorded on central leads in SRT and DRT. During passive viewing, pre-stimulus activity was not detected. In contrast, for auditory modality a slow rising positivity over PFC characterized the pre-stimulus phase in all conditions. The motor preparation was observed on more posterior parietal regions in SRT and DRT. In conclusion, the brain activity anticipating a visual or an auditory task is remarkably different.

P7.175 MULTISENSORY INTEGRATION AND EXCITATION-INHIBITION. INTERPLAY BETWEEN GENETIC, BIOCHEMICAL AND NEURAL MARKERS.

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Multisensory integration is subject to temporal rules. Information from different sensory modalities is integrated within a range of temporal offsets, known as the temporal binding window (TBW). A major characteristic of the TBW is its high variability across individuals. We aimed at finding possible neurobiological predictors of such inter-individual differences. It has been shown that the temporal structure of scale-free brain dynamics is described by power-law exponent (PLE). PLE positively correlates with brain glucose metabolism, which in turn is closely linked to both glutamate- and GABA-ergic neurotransmissions. Drawing from this evidence, we hypothesized PLE during rest would mediate the impact of glutamate- and GABA-ergic neurotransmissions on audio-tactile integration (TBW). We indexed excitatory and inhibitory neurotransmissions at biochemical (Glx and GABA concentrations) and genetic (polymorphisms affecting specific glutamate- and GABA- related genes) levels. Our results showed that Glx in the auditory cortex interacted with individual genetic profiles to predict PLE, such that, at low values of genetic score, Glx had a positive effect on PLE. In turn, PLE negatively predicted TBW. Importantly, when we adopted a moderated mediation approach to test the effect of Glx concentrations and individual genetic profiles on audiotactile integration (TBW), we found this effect to be significantly mediated by the magnitude of PLE at low and intermediate values of the individual genetic score. Taken together, our results suggest that the ability to integrate multisensory information is biologically predisposed by GABA- and glutamate-ergic neurotransmission, through its impact on the temporal structures of resting brain activity.

P7.176 NEURAL SUBSTRATES OF EARLY DATA REDUCTION IN THE VISUAL SYSTEM

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The visual system needs to extract rapidly the most important elements of the external world from a large flux of information, for survival purposes. A rapid (as fast as 20 msec) and reliable detection of visual stimuli is essential for triggering autonomic responses to emotive stimuli, for initiating adaptive behaviors and for orienting towards potentially interesting/ dangerous stimuli. The limitations to the brain capacity to process visual information, imposed by intrinsic energetic costs of neuronal activity, and ecological limits to the size of the skull, require a strong data reduction at an early stage, by creating a compact summary of relevant information, to be handled by further levels of processing. Recently we formulated a model of early vision allowing a much stronger data reduction than existing vision models based on redundancy reduction. Optimizing this model for best information preservation under tight constraints on computational resources yields surprisingly specific a-priori predictions for the shape of physiological receptive fields of primary visual areas, and for experimental observations on fast detection of salient visual features by human observers. Here we investigate the anatomical substrates of these fast vision processes by adopting a flicker adaptation paradigm that has been shown to impair selectively the contrast sensitivity of the Magnocellular pathway (Zhuang 2015). Results show that thresholds for discrimination of briefly presented sketches, increase after adapting to a uniform flickering field, while contrast thresholds for orientation discrimination of a grating do not change, suggesting the involvement of the MC pathway in this compressive visual stage.

P7.177 NEURAL INTEGRATION OF TRIMODAL SENSORY STIMULI: MORE IS BETTER

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Empirical observations and theoretical assumptions on how the brain combines the often-disparate sensory streams are primarily based on crossmodal stimulation maximizing temporal aspects rather than semantic meaning where crossmodal combinations auditory, visual, or tactile stimuli dominate. The present study aimed to examine the neural mechanisms of trimodal sensory integration of semantically congruent combinations of visual, auditory, and olfactory stimuli. Specifically, we determined differences and similarities between trimodal and crossmodal sensory integration. In addition, we investigated modality independent mechanisms of crossmodal integration of semantically congruent stimulus combinations. Participants were exposed to uni-, cross-, and trimodal combinations of short video sequences of familiar objects with corresponding sounds and odors; cerebral processing was acquired using fMRI. The task was to count the number of sensory modalities presented. Crossmodal and trimodal integration, as well as differences thereof, were assessed using corresponding supra-additive interaction and conjunction analyses between individual contrasts. Neural integration of congruent trimodal stimuli was greater than corresponding crossmodal integration in bilateral intraparietal sulcus (IPS) and inferior frontal gyrus (IFG). Trimodal stimuli produced both larger signal values and spatial extension than crossmodal stimuli. Modality independent crossmodal sensory integration activated IPS, middle and superior frontal gyrus, insula cortex, and IFG. Taken together, these data suggests that trimodal sensory stimuli are processed to a great extent within the same neural network as crossmodal stimuli but that trimodal stimuli elicits greater neural processing demands.

P7.178 SNIFFING OUT A VISUAL THREAT

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Facial expressions are integral to the detection of social threats, but are rarely perceived in isolation. Social interactions are multisensory events, and a threatening facial expression exists in a broader context of visual, auditory, and chemosensory stimuli. Recent investigations have begun to describe how these contextual cues of an individual's state (emotion, health) or traits (sex, age) can influence the processing of facial emotional expressions. We tested whether chemosensory cues of identity in body odor can contextually modulate electrophysiological, psychophysiological, and behavioral measures of facial emotional expression processing. In Study 1, we measured event-related potentials to angry and neutral schematic faces presented to twenty-one participants in the presence of Strangers' body odor, Self body odor, or an odorless control. In Study 2, we measured the skin conductance and reaction times of nineteen participants performing a visual search task for an angry or happy schematic face among neutral distractor faces while smelling either Stranger or Self body odor. In both studies, odors were delivered intra-nasally by computer-controlled olfactometer, and perceptual ratings of odor intensity, pleasantness, and familiarity were collected. Event-related potentials revealed that Stranger and Self body odors differentially affect both early, sensory and later, cognitive stages of facial emotional expression processing. In addition, smelling Strangers increases physiological arousal to facial expressions and speeds the detection of target facial expressions in an emotion-independent manner. These studies indicate that the chemosensory presence of an unknown individual negatively biases the processing and perception of facial emotional expressions.

P7.179 CATEGORICAL RESPONSES TO OBJECT SOUNDS BUT NOT TO VOICES IN THE OCCIPITO-TEMPORAL CORTEX OF EARLY BLIND INDIVIDUALS

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How visual experience shapes the categorical response properties of the ventral auditory and visual streams has raised considerable attention. We used fMRI to characterize brain responses of early blind and sighted individuals to object sounds, human voices and scrambled control sounds in a task that minimized the involvement of imagery. A double dissociation was evidenced for the first time in bilateral auditory cortex between responses to object sounds and voices in both groups. Selective responses to object sounds were observed in A1, planum temporale and rolandic operculum while selective responses to voices were observed in superior temporal sulci. Between group-comparisons revealed that object sounds elicited enhanced selective crossmodal responses in extrastriate occipital regions in early blind subjects. These crossmodal responses encompassed regions traditionally involved in visual object identification (LOC) and more posterior regions that have been previously suggested to support semantic processing in the blind. In contrast, vocal sounds did not elicit crossmodal categorical responses in the occipito-temporal cortex in either group. Altogether, these findings demonstrate the presence of categorical responses to object sounds but not to voices in the occipito-temporal cortex of early blind individuals. This suggests that separate auditory domains do not have the same potential to drive selective auditory recruitment of occipito-temporal regions in the absence of developmental vision. The presence of object-selective responses in LOC in the blind group provides the first evidence that early visual deprivation drives this region to represent object sounds in the absence of shape information.

P7.180 INTRACRANIAL EEG RECORDINGS IN HUMANS REVEAL FREQUENCY SPECIFIC MULTISENSORY INTEGRATION IN PRIMARY AUDITORY AND VISUAL CORTICES

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We investigated early multisensory integration (EMSI) in primary visual (VC) and auditory cortices (AC) using intracranial EEG recordings in humans. Eight drug-resistant patients implanted with intracerebral electrodes, were presented with auditory (A), visual (V) and audiovisual (AV) stimuli. Comprehensive time-frequency analyses were computed for theta-alpha (5-13 Hz), beta (13-30 Hz), gamma (30-80 Hz) and high gamma (HGP1: 80-140 Hz; HGP2: 140-200 Hz) bands. Analyses were computed for data recorded at contacts of interest (COIs) in primary visual (n = 48) and auditory cortices (n = 47). EMSI (temporal window: 0-150 ms) was first assessed by comparing the AV condition vs the strongest unimodal condition in each COIs (maximum model). In addition, the linearity of MSI was assessed by comparing AV+Neutral vs A+V conditions (additive model). EMSI was observed in all frequency bands, although with different percentages in the different cortices (VC: from 38% to 72% of COIs depending of the frequency band; AC: from 13% to 42% of COIs depending of the frequency band). The highest percentages of EMSI were observed in beta and HGP bands. Non-linear MSI was observed in both cortices, with the highest percentage in the gamma band. In conclusion, we demonstrate reliable evidence of early MSI in both primary cortices, although with higher percentages in VC than in AC. The observed differences across time-frequency domains suggest different neurophysiological mechanisms at the basis of EMSI.

P7.181 EFFECTS OF HAND AND GAZE LOCATION ON MOTOR EVOKED POTENTIAL

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We performed two experiments to test hypotheses regarding effects of gaze and hand position on motor cortex excitability measured by TMS. First, we reasoned that if the left hemisphere is dominant for motor attention, one would expect that motor evoked potentials (MEPs) would be larger when the right or left hand is placed in the right side of space. Second, although the locations of gaze and action may be dissociated, they are usually linked; on the assumption that visual attention typically follows gaze, we predicted that gazing at the hand would increase MEPs as compared to when hand location and gaze were dissociated. Experiment 1 tested these predictions by measuring MEPs for the right hand of 20 right-handers in 4 conditions, generated by crossing the variables of side of hand (R/L) and direction of gaze (R/L) relative to the body midline. There was a main effect of side of gaze with MEPs larger on the right than left (107% vs 93%, $p < .01$). There was also an effect of congruence such that MEPs were larger when subjects did NOT gaze at their hand (105% vs 95%, $p < .01$). Experiment 2 was identical except the left hand was tested. The effect of gaze was replicated with the LEFT hand of right-handers in that MEPs were larger for the left hand when gazing to the right side of space ($p<.03$). These data support the hypothesis that the left hemisphere is dominant for motor attention and that this is independent of effector. The data are INCONSISTENT with the hypothesis that effects of gaze-hand congruence and motor attention would be additive. One interpretation of the latter finding is that increased MEPs when gaze and hand position are dissociated reflects an increased need for surveillance of the environment outside of the field of gaze.

POSTER SESSION 8: HIGHER LEVEL FUNCTIONS AND EMOTION

P8.182 THE EFFECT OF PSEUDO-WORD LABELS ON THE PERCEPTION OF MINERAL WATER.

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Word-sound symbolism has been shown to affect different aspects of our sensory experiences. The present study investigated the effect of the pseudo-word labels, on people's perception of mineral water (still, slightly carbonated, carbonated). Participants were required to evaluate freshness, pleasantness, level of carbonation and lightness of the water served in three identical plastic cups, using visual analogue scales. The cups could be labeled with the pseudo-word "Maluma" or "Takete", or present no label. The results showed that the participants perceived slightly carbonated water as fresher when served in a cup with no verbal label, as compared to a cup labeled with the pseudo-word "Maluma" or "Takete". By contrast, people evaluated slightly carbonated water as less carbonated when presented in a cup labeled with the pseudo-word "Maluma", as compared to the pseudo-word "Takete". In an additional control experiment, we showed that participants significantly matched the pseudo-word "Maluma" with the word 'warm' and with 'still water', and the pseudo-word "Takete" with the word 'cold' and with 'carbonated water'. Taken together, the results reported here suggest that people's perception of mineral water can be modulated by the label that is used to identify the container where the liquid is served. This

effect might be due to a possible role of some qualities of the label (e.g., the sound of the words used) in affecting people expectation of the liquid that is served in the cups.

P8.183 TASK DEPENDENT AUDITORY SPATIAL IMPROVEMENT AND VISUAL ENVIRONMENTAL OBSERVATION.

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The visual information is fundamental for space perception and this modality can influence the auditory space estimation. Many studies show that the presence of simultaneous visual and auditory cues improves precision of the final multisensory estimate. An interesting question is whether a previous visual cue related to the environmental observation can be used to improve a sequent auditory estimation. Here we tested this point by testing audio precision of sighted blindfolded subjects before and after the observation of the environment in which they are performing the task and also with their eyes opened during the task. Improvement occurs on the auditory task already after environmental observation. Interestingly the same improvement was not present if the task was performed in an anechoic room. We discuss these results in terms of visual calibration over the auditory modality.

P8.184 HAND POSTURE ALTERS PERCEIVED FINGER NUMEROSITY

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Patients with posterior parietal lesions commonly fail in identifying their fingers, a condition known as finger agnosia. Recent research has shown that healthy people may also perform poorly in certain tasks of finger identification. Here, we investigated whether the representations of finger numerosity is modulated by the spatial relationships between the fingers. We used the 'in between' test, a classical measure of finger agnosia, in which participants estimate the number of unstimulated fingers between two touched fingers. Stimulation consisted of pairs of mechanical tactile stimuli delivered on the back of the second phalanx of the fingers of one hand. Across blocks, the fingers were placed in three postures: (1) with fingers touching each other, (2) fingers separated by one centimetre, or (3) fingers spread to the maximum comfortable splay. Participants judged the number of unstimulated fingers 'in between' the two touches and responded vocally as quickly and accurately as possible. Critically, participants gave larger numerosity estimates when the fingers were positioned far apart compared to when they were close together or touching. Our results demonstrate that increasing the spatial distance between the fingers makes participants experience the fingers as more numerous.

P8.185 THE EFFECTS OF VIBRATION AND SOUND ON COMFORT AND TASK PERFORMANCE

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Sound and vibration have significant impacts upon performance and comfort and therefore are important considerations for industrial design and research. While sound and vibration are intrinsically linked due to the nature of their properties of propagation, human perception of these stimuli differs and draws on different modalities. Humans typically perceive vibration up to around 100Hz and sound within 50Hz-10kHz. This research addresses the question how do these sensory modalities that represent different frequency ranges interact in terms of perception and comfort. The study uses a factorial design to measure the impact of sound and vibration on subjective comfort ratings and objective performance measures. 24 participants judged comfort levels using a standardized 26 item, 100-point Likert scale comfort questionnaire. The objective measure of the effect of sound and vibration was the performance on a speech intelligibility task in which participants identified meaningless vowel-consonant-vowel syllables while exposed to aircraft noise and vibration patterns. Since simulation fidelity affects comfort ratings participants were seated in rows of aircraft seats to simulate a cabin environment. Audio was presented via headphones at 70dB(A) while one row of seats was provided with vibration cues via a low frequency audio transducer. The questionnaire data was analyzed using factor analysis to determine common themes; this was followed by paired t-tests to identify systematic differences between conditions. The performance data was analyzed in the form of an ANOVA and subsequent Bonferroni adjusted post-hoc tests. It was found that vibration and sound make independent contributions to comfort ratings and objective performance.

P8.186 THE COGS (CONTEXT-OBJECT-GOALS) FRAMEWORK FOR MULTISENSORY PROCESSING

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If multisensory objects are detected faster than their unisensory counterparts, is it because of their perceptual/semantic redundancy or because they simply contain more task-relevant features? Our understanding of how perception operates in real-world environments has been advanced by studying multisensory processing and control mechanisms (attentional and otherwise), but in a largely independent manner. Critical insights into the mechanisms underlying multisensory processing have been provided by studies combining brain mapping methods together with distinctive paradigms, varying task demands as well as types of stimulus pairings. Past work revealed that some multisensory processes are determined by the observer's goals, while others occur independently. However, other dimensions than goal-dependence are necessary to explain the full plethora of multisensory effects at the brain and cognitive level. A novel, "COGs" framework is presented that construes multisensory processes as lying on continua along three axes: (1) Context-dependence, (2) Object-dependence and (3) Goal-dependence. This new framework is predicated on the observation that some multisensory processes are triggered even by arbitrary pairings, while others are engendered by objects from specific stimulus categories that activate distinct brain networks. Moreover, some processes transpire irrespectively of the paradigm or population, while others are strongly modulated by the specific context, including decisional factors, in which the stimuli appear. The COGs framework is the first to integrate seemingly contradictory findings from experiments employing distinctive experimental setups and stimulus pairings. The COGs framework also reinforces the growing consensus that multisensory processing is not specialised, but rather subserved by mechanisms more general in nature.

P8.187 GROUPING BY PROXIMITY FACILITATES HAPTIC ENUMERATION OVER THE FINGERS

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Spatial arrangement is known to influence enumeration times in vision. In haptic enumeration it has been shown that dividing the total number of items over the two hands can speed up enumeration. Here we investigated how spatial arrangement of items and non-items presented to the individual fingers impacts enumeration times. More specifically, we tested whether grouping by proximity facilitates haptic serial enumeration (counting). Participants were asked to report the number of tangible items, amongst non-items, presented to the finger pads of both hands. In the first experiment, we divided the tangible items in one, two or three groups that were defined by proximity (i.e. one non-item in between two groups), and found that number of groups and not number of items were the critical factor in enumeration times. In a second experiment we found that this grouping even takes place when groups extend across fingers of both hands. These results suggest that grouping by proximity facilitates haptic serial enumeration and that this grouping happens on a spatial level instead of somatotopic. Our results support the idea that grouping by proximity, a principle introduced in vision, also greatly affects haptic processing of spatial information.

P8.188 VISUAL, HAPTIC, AND EMOTIONAL CATEGORIZATION

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The current study examined the relationships between colour, texture, and emotional categorization in different modalities, namely vision and haptics. Participants completed three categorization tasks using different stimuli: colours, emotional faces, and textures. Colour Categorization task used colour plates arranged in order according to their hue, and participants had to draw any number of vertical lines between the plates separating different colour categories, as well as to name each category. The Emotional Faces Categorization task used the same procedure, but applied to the sequence of morphed faces representing basic emotions and the transitions between them. Texture Categorization task used the same procedure, but applied to the texture plates arranged in order according to the grain sizes. Participants were blindfolded during this task, they indicated the borders manually, and named the categories verbally. In addition, they completed Colour Discrimination Task, assessing colour perception deficiency, which used the same colour plates as in Colour Categorization task. The analysis revealed significant relationship between categorization in different modalities. Colour Discrimination performance tended to positively correlate with Colour Categorization only.

P8.189 AUDITORY-VISUAL FEARFUL STIMULI AMPLIFY NEGATIVE FEELINGS AS A FUNCTION OF THEIR DISTANCE TO THE PERCEIVER

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Affective events often convey emotional information through multiple senses. Yet, little is known about how the emotional experience elicited in the perceiver is influenced by multisensory events. Given the close links between space and multisensory processes on one hand and space and emotion on the other hand, we hypothesized that the spatial location of a fearful event interacts with the sensory channel of presentation to influence emotional experience. Whether the event is within or outside the peri-personal space (PPS), i.e. the space near the body, could have a role in the elicited negative emotional experience. Two groups of participants (crowd-fearful and non-fearful) navigated in a virtual environment modeled after Trinity College Dublin, containing crowd stimuli presented through the auditory channel, the visual channel or both. They reported the discomfort they experienced, using Subjective Units of Distress, as the crowds were located at close (2m) or far (8m) distances from them. We compared the discomfort reported for unimodal (visual or auditory) and bimodal (auditory–visual) crowd stimuli as a function of their location. Crowd-fearful participants reported more intense discomfort in response to bimodal auditory-visual crowds compared to unimodal crowds. This effect selectively occurred when the crowds were located at a close, not at a far, distance from participants. These results suggest that, spatial and multisensory characteristics of affective events combine to induce and modulate emotional experience.

P8.190 SEEING AND TOUCHING VIRTUAL TEXTURES: A STUDY ON TACTILE HEDONIC PERCEPTION

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A large number of studies has investigated the multisensory interactions affecting the simultaneous presentation of visual and tactile stimuli. However, very little is known regarding the effects of the interaction between these senses on hedonic perception, especially when the presentation of the stimuli is mediated by haptic interfaces. Hence, the present study aimed at assessing the role of vision over the exploration of virtual textures rendered by means of a haptic force-feedback device. The participants were simultaneously presented with combinations of different pictures representing common materials (glass, plastic, rubber and steel) and different tactile experiences reproduced by means of a Geomagic® Touch haptic device. In order to provide the tactile sensations, both the static and dynamic friction coefficients of the device were varied. The participants were required to rate the pleasantness and roughness of each virtual texture explored using visual analogue scales. The time spent during each exploration was also recorded. The results revealed that both the pleasantness and roughness judgments varied as a function of both the tactile sensations reproduced by the haptic device (related to the friction parameters set) and the specific visual stimuli simultaneously presented. Also, the participants explored the textures for less time during the multisensory visuo-tactile condition compared to a unisensory tactile exploration condition. Taken together, these results clearly suggest that vision modulates tactile hedonic perception, when tactile sensations are simulated via a haptic device. Furthermore, they offer interesting suggestions for the reproduction of more pleasant, and even more realistic, virtual textures.

P8.191 CHARACTERIZING PROTOTYPE EFFECTS ON SPATIAL MEMORY

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Humans naturally divide space into categories, forming boundaries and central values. Within these boundaries, memories of the spatial location of visual stimuli are thought to be weighted by their distance to an assumed centre. This produces biases in spatial memory towards this so-called prototype, known as category effects. Previous studies have tested category effects using circular shapes, showing systematic response biases towards the centroids of each quadrant. These biases seem to reflect a subdivision of the shape along the horizontal and vertical meridians in retinal space. However, this seemly universal division of space might not be relevant when the intrinsic geometry of the shape facilitates other subdivisions. To test this possibility, we compared categorical effects across different geometrical shapes. Participants had to remember the location of a briefly presented dot in a square, rectangle, circle and rhombus. We found similar patterns of biases across shapes, for the square, rectangle and circle. That is, subjects misplaced dots towards the centroids of each quadrant, as if they had imposed horizontal and vertical boundaries dividing the shapes into quadrants. Analyses of cosine similarity between localization errors and predicted errors towards prototypes confirmed this pattern. We did not find any systematic bias when the remembered dots were presented inside a 90 deg. rotated square (a rhombus shape). This clearly speaks against a universal division of visual space along the horizontal and vertical meridians in retinal space. Instead, humans appear to divide visual space as a function of the shape of surrounding boundaries.

P8.192 DO REPRESENTATIONS OF MAGNITUDE SHARE A SINGLE MENTAL SPACE? AN AUDITORY AND AUDIO-VISUAL TEST USING LOUDNESS AND LUMINANCE

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The aim of the present study is to investigate whether the spatial mapping of magnitude, robustly documented for numerical magnitudes, such as digits and number words, as well as sensory magnitudes such as object size and pitch, is as domain-general as supposed. Specifically, we will explore the effect of compatibility of response mapping (from small to large) for unimodal and multisensory stimuli of intensity. A set of three experiments will be presented to test for a Stimulus Response Compatibility (SRC) effect for loudness and how this varies as a function of 1) the orientation of the response axis (horizontal vs. vertical), 2) the nature of the stimulus format (discrete vs. dynamic) and 3) concurrent visual stimulation varying in degrees of luminance. Using a two-tone discrimination task, results from experiment 1 show a Spatial-Loudness Association of Response Code (SLARC) with participants responding faster to quieter sounds when the response option is on the left and louder sounds to the right. No effect was seen for responses on a vertical axis. Moreover, the effect is seen when using a pair of discrete stimuli but not when dynamic, continuous stimuli (either increasing or decreasing in loudness) are presented. In the bimodal presentations (visual and auditory stimuli), results show a congruency effect between loudness and luminance when using both the discrete or dynamic stimuli. These results have theoretical and methodological implications for the widely discussed link between space and magnitude and the idea of an amodal representation of magnitude.

P8.193 INDIVIDUAL DIFFERENCES IN ASSOCIATION BETWEEN SPATIAL DIRECTION AND COLOR IMAGE

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Cross-modal congruency demonstrates perceptual features can be associated beyond modalities (e.g., color-shape, color-taste). In the present study, we investigated whether spatial directions (up, down, left, right) can be associated with particular colors. A preliminary survey, wherein participants chose the most suitable color for each direction, showed that some particular combinations were preferred (e.g., “up-red”, “down-blue”, “left-blue or green”, and “right-red”). In a behavioral experiment, we examined whether the association between spatial direction and color influences discrimination of target. Prior to the experiment, each participant chose his or her preferable combinations between the spatial direction and colors. At the beginning of a block, four pairs of directions and colors were instructed as the targets. In each trial, a word that meant one of the four spatial directions was presented on a colored patch. Participants indicated whether the stimulus was target or not as quickly as possible. The result showed that the response was faster for the targets of preferable combinations. Furthermore, autism-spectrum quotient (AQ) scores and Oxford Schizotypal Personality Scale (STA) were negatively correlated with the differences between response times for the targets of preferable combinations and those for other targets. To sum, these results suggested that spatial directions were potentially associated to particular colors and the association can impact on behavioral performances. In addition, the effects of color-space association may be weaker in persons who have stronger autistic or schizophrenic traits.

P8.194 FEELING ANIMACY FROM TACTILE VIBRATION

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Animacy is a feeling that something other than animal is animate. Thus far, the feeling of animacy has been mainly investigated in terms of visual perception/cognition. However, we can also feel animacy through the sensory modalities other than vision. In the present study, we investigated how tactile vibration induces the feeling of animacy. First, we measured the acceleration of fishing rod during biting of a fish. In the experiments, we presented the acceleration time series as a tactile vibration applying various frequency filters. Observers rated how strongly they feel animacy from the tactile vibration on a 7-point scaling. We found that the low-pass filtered vibration with the cut-off frequency less than 64Hz induced the strong feeling of animacy. Furthermore, we also observed that the strength of animacy changed qualitatively around 40-80Hz, and that the phase randomization of the tactile vibration reduced the feeling of aniamcy when the vibration contains the low frequency component less than 32Hz. These results demonstrated that the feeling of animacy depends strongly on the frequency characteristics of the tactile vibration, and that phase information also influences the feeling of animacy.

P8.195 THE PERCEPTION OF ANIMACY FROM MULTIPLE-STIMULUS DIMENSION IN PRIMATES

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The perception of animacy is the ability to detect animal specific traits such as goal-directedness from motion information. Previous studies in humans demonstrated that this motion-based processing can be altered by another stimulus-dimension such as shape (Gao et al., 2009) and modulates the motor reactions of observers to the stimuli (Kanakogi et al., 2013). In the present study, these characteristics in the perception of animacy in Japanese macaques (Macaca fuscata) were analyzed. Two monkeys were trained to discriminate Chasing sequences (animated motions of two circles) from Random sequences. In testing, the correlation and the distance

between the two trajectories in Chasing were altered to examine whether the monkeys performed by focusing these physical properties rather than animacy. Results showed each property didn't work solely as the discriminative cue, suggesting monkeys perceived animacy from Chasing. The subsequent experiment was conducted to examine whether the animals generalize their discrimination to the shape information. In the test sequences, the moving circles were replaced with ellipses, and the axes of each object were controlled. One monkey participated, and responded to all stimuli in which the axis of one object always directed to the other. Moreover, through the training, her touch responses were frequently converged on Chasing motion paths. These suggest that the animacy detection from motion was affected by shape information, and the animacy motions can modulate motor reactions of observer. Results of the monkey might reflect the same cognitive mechanism underlying the responses to the specific motion patterns in humans.