International Multisensory Research Forum 17th annual meeting

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Suzhou, China

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IMRF2016 Abstract Book

Suzhou, China

June 15th~June 18th

KEYNOTE SPEAKER 1 16:15, June 15th

MULTISENSORY MECHANISMS OF BODY SELF-PERCEPTION

H. Henrik Ehrsson

Department of Neuroscience, Karolinska Institutet, Sweden

Ask any child if his hands belong to him and the answer will be “Of course!” But how does the brain actually identify its own body? Our hypothesis is that parts of the body are distinguished from the external world by the patterns they produce of correlated information from different sensory modalities (vision, touch and muscle sense). These correlations are hypothesized to be detected by neuronal populations in frontal and parietal areas that integrate multisensory information from the space near the body. We have used a combination of functional magnetic resonance imaging and human behavioral experiments to present experimental evidence in support of these predictions. To change the feeling of body ownership, perceptual illusions were used where healthy individuals experienced that a rubber hand was their own, that a mannequin was their body (“body-swap illusion”), or, that they are outside their physical body and looking at it from the perspective of another individual (“out-of-body illusion”). By clarifying how the normal brain produces a sense of ownership of one’s body, we can learn to project ownership onto prosthetic devices in amputees. This will facilitate the development of advanced prosthetic limbs that feels just like real limbs.

KEYNOTE SPEAKER 2 18:05, June 16th

NEURONAL ACTIVITY IN THE MONKEY PREFRONTAL CORTEX IN A VISUAL-HAPTIC CROSS-MODAL DELAY TASK

Yongdi Zhou

NYU-ECNU Institute of Brain and Cognitive Science at NYU Shanghai, China

Studies have indicated that neurons in the monkey dorsal prefrontal cortex (DLPFC) integrate information across modalities and maintain it throughout the delay period of working-memory (WM) tasks. However, the neural mechanisms of this crossmodal temporal integration in the DLPFC are still not well understood. In the present study, to further elucidate the role of the DLPFC in crossmodal WM, we trained monkeys to perform visuo–haptic (VH) crossmodal and haptic–haptic (HH) unimodal WM tasks that required the animals to memorize a visual cue (in the VH task), or a haptic cue (in the HH task) for a haptic choice. The neuronal activity recorded in the DLPFC in the delay period of both tasks indicates that the early-delay differential activity probably is related to the encoding of the sensory component (modality-dependent, sample information), that the late-delay differential activity reflects the associated action component (modality-independent, active recall and maintenance of sample information for subsequent action) of haptic choice in both tasks, and that the sustained whole-delay differential activity likely bridges and integrates the sensory and action components. Our findings may clarify the neural mechanisms by which the cerebral cortex stores information in working memory, a cognitive function of prime importance in the coordination of behavior, speech, and reasoning.

KEYNOTE SPEAKER 3 18:05, June 17th

AUDITORY INFLUENCES ON VISUAL ATTENTION AND PERCEPTION

Steven A. Hillyard

Professor Emeritus, Department of Neurosciences, School of Medicine, UC San Diego

It is well established that directing attention voluntarily to an object's location results in the multi-modal facilitation of the object's properties. Evidence is also mounting that salient sounds may attract attention involuntarily and facilitate the processing of visual stimuli at the sound's location. This cross-modal capture of visual attention may occur even when the attracting sound is irrelevant to the ongoing task and is non-predictive of subsequent events. A slow positive component in the event-related potential (ERP) elicited by a salient sound was found to be localized to the visual cortex. This neural sign of visual cortex activation was predictive of enhanced perceptual processing and was paralleled by a desynchronization (blocking) of the ongoing occipital alpha rhythm. Further research is needed to determine the nature of the relationship between the slow positive ERP evoked by the sound and the alpha desynchronization and to understand how these auditory-evoked neural events contribute to improved visual-perceptual processing.

SPECIAL LECTURE 17:25, June 16th

MULTISENSORY CONTROL AND LEARNING OF COGNITIVE ROBOT SYSTEMS

Jianwei Zhang

Institute TAMS (Technical Aspects of Multimodal Systems), Department of Informatics, University of Hamburg

In a dynamic and changing world, a robust and effective robot system must have adaptive behaviors, incrementally learnable skills and a high-level conceptual understanding of the world it inhabits, as well as planning capabilities for autonomous operations. Future intelligent control systems will benefit from the recent research on neurocognitive models in processing multisensory data, exploiting synergy, integrating high-level knowledge and learning, etc. I will first introduce multisensory integration methods for intelligent control of robots. Then I will present our investigation and experiments on synergy technique which uses fewer parameters to govern the high DOF of multifinger robot movement. The third part of my talk will demonstrate how an intelligent system like a robot can evolve its model as a result of learning from experiences; and how such a model allows a robot to better understand new situations by integration of knowledge, planning and learning. I will show some integrated results of operational mobile robot platforms with grasping facilities in a restaurant service scenario.

SYMPOSIA1: 40 YEARS OF THE MCGURK-MACDONALD EFFECT

Thursday June 16th 08:30-10:10

Organizers: Michael Beauchamp, Jean Vroomen & Salvador Soto-Faraco

Introduction

In 1976, Harry McGurk and John MacDonald published a seminal Nature paper entitled "Hearing lips and seeing voices". They discovered a fascinating multisensory illusion in which incongruent *visual* speech information dramatically changes the percept of *auditory* speech. This discovery was revolutionary because it provided irrefutable evidence that speech is a multisensory process, rather than purely an auditory one. Since then, McGurk and MacDonald (1976) has been cited more than 4400 times, easily making it one of the most influential manuscripts in the entire multisensory literature.

To celebrate the 40th anniversary of this epochal finding, we propose a symposium devoted to the illusion discovered by McGurk and MacDonald. The first speaker, John MacDonald, will offer first person insights on the discovery of the illusion (Harry McGurk is deceased) and the context that framed the research. The original work by McGurk and MacDonald focused on the development of audiovisual speech perception, and Julia Irwin will discuss the utility of the illusion for understanding speech perception in special populations. Michael Beauchamp will discuss brain imaging and computational modeling studies of individual variability in the illusion, while Salvador Soto-Faraco will present work on the neural response to the incongruence between the auditory and visual modalities that is at the heart of the McGurk Effect. Jean Vroomen will discuss behavioral studies linking the McGurk effect to two other important phenomena in speech perception, the contribution of lipreading to speech in noise and the ventriloquist effect.

S1.1 HEARING LIPS AND SEEING VOICES: A LOOK BACK 40 YEARS

John MacDonald, retired

John MacDonald, co-discoverer with Harry McGurk, will cover the lead up to and discovery of the McGurk illusion, which lead to the seminal paper published in Nature in 1976. The presentation will include an outline of the infant perception research project being conducted at the time; the rationale for the generation of the initial stimuli and the construction of the first exemplars. The serendipitous nature of the finding will be described and how the investigators tried to locate the illusion within the existing literature. The presentation will also cover some of the early studies conducted and the reaction and non-reaction to the publication in Nature. Professor MacDonald will also cover some of the host of studies that have been inspired by the illusion and suggestions as to its significance.

S1.2 SEEING TO HEAR: AUDIOVISUAL SPEECH PERCEPTION AS A TOOL FOR UNDERSTANDING SPECIAL POPULATIONS

Julia Irwin

Haskins Laboratories, USA

Julia Irwin's research assesses perception of audiovisual speech perception in the context of development of typical and atypical language development. This work makes use of varied methodological techniques such as electroencephalography (EEG) and event related potentials (ERP) paired with eye-tracking technology. Her studies have addressed not just typically developing children, but those with speech/language delays, including autism spectrum disorders and speech sound disorders. The goal of gathering this knowledge is ultimately translational: to help children with peech, language, and literacy difficulties through improved early evidence-based assessment, intervention and prevention.

S1.3 MODELS AND MECHANISMS OF MULTISENSORY SPEECH PERCEPTION

Michael Beauchamp

Baylor College of Medicine, USA

Our understanding of the McGurk effect has been challenged by the discovery that there is tremendous interindividual variability: some normal individuals never experience the illusion, while others always do. Beauchamp will discuss behavioral, neuroimaging, and computational modeling studies that offer an explanation for this variability. In particular, differences in the neural activity in the superior temporal sulcus of both adults and children, and in the eye movements made by subjects as they perceive audiovisual speech, offer clues as to the source of interindividual variability.

S1.4 THE ROLE OF ATTENTION AND CONFLICT IN THE MCGURK-MACDONALD EFFECT

Salvador Soto-Faraco

Universitat Pompeu Fabra, Spain

The McGurk illusion has been widely used to infer general properties of multisensory integration mechanisms across a variety of contexts. What we contend here is that AV integration during the McGurk effect may be different from normal AV speech integration, because it arises from the resolution of a conflict. We present fMRI and EEG evidence that McGurk stimuli engage a general-purpose conflict network (involving the ACC and the IFG), typical of non-speech conflict (i.e. Stroop, Simon task). We suggest that this network may be in fact critical in the resolution of the AV speech conflict and the posterior emergence of the McGurk illusion.

S1.5 LINKING THE MCGURK-MACDONALD EFFECT TO LIPREADING AND THE VENTRILOQUIST EFFECT

Jean Vroomen
Tilburg University, Netherlands

Dr. Vroomen will discuss behavioral studies linking the McGurk effect to two other important phenomena in speech perception, lipreading and the spatial ventriloquist effect. The underlying notion for both effects is that the brain integrates, despite small deviances in phonetic detail or space, signals from different modalities into a single multisensory event. Critically, when the deviance between the auditory and visual signals is too large, the signals likely originate from different events, in which case there is no reason to “bind” the information streams, and there is then also no reason to fuse, integrate, or recalibrate the senses, because two separate events are perceived. This notion raises the question of whether spatial and phonetic integration actually depend on the same a priori criteria for intersensory binding. Data will be presented demonstrating that audiovisual binding in space may be different from audiovisual binding in speech.

SYMPOSIA2: ADAPTATION IN SPACE AND TIME

Thursday June 16th 10:20- 12:20

Organizers: Jeffrey Yau & Fang Jiang

Introduction

Adaptation is well-documented phenomenon in which neural response properties change based on recent stimulus history. Such neural changes can lead to compelling alterations of perceptual experiences. Because adaptation can be used to reveal response selectivity, it has been referred to as “the psychologist’s microelectrode”. Adaptation has also been exploited in functional neuroimaging studies to infer population-level tuning properties. This symposium highlights recent investigations that use adaptation in behavioral and fMRI paradigms to understand sensory processing in temporal and spatial domains. Our speakers comprise an international panel of junior and senior investigators who use adaptation as a tool to examine how information is processed within modalities, across modalities, and even across time and space. Committed speakers include:

S2.1 MOTION SYSTEM IN TOUCH

Scinob Kuroki

NTT Communication Science Laboratories, Japan

Tactile motion provides critical information for perception and manipulation of objects. However, the underlying mechanism of it remains enigmatic. Some research even find that perceived direction of unambiguous rotating tactile stimuli is easily reversed, suggesting possible critical discrepancy in motion mechanism between touch and other modalities. To explore the neural mechanism of motion perception, the motion adaptation phenomenon can be a useful probe. Whether the motion aftereffect (MAE) itself occurs in touch had been a matter of long debate though, we find robust protocol to produce tactile MAE by using apparent motion. We investigated within and inter-finger motion system by tactile MAE. Also, we shed light on the mechanisms underlying directional remapping in touch by examining whether finger posture modulates the direction of the tactile MAE induced by inter-finger apparent motions. In the experiment, we introduced conflicts in the adaptation direction between somatotopic and environmental spaces by having participants change their finger/hand posture between adaptation and test phases. What we found was that the tactile MAE was induced in accordance with the motion direction determined by the environmental, rather than the somatotopic space. In addition, we found that tactile MAE is vulnerable to hand motion and easily diminished by hand posture change.
Bullet points:

S2.2 CROSS-MODAL MOTION PROCESSING AFTER SIGHT RECOVERY

Fang Jiang

University of Nevada, Reno, USA

Recently we showed that hMT+ responses to auditory motion are associated with subjects’ decisions about auditory motion direction in early blind individuals (Jiang et al., 2014). Here, we examine whether these cross-modal motion responses arise ‘de novo’ or co-opt residual visual architecture, by comparing visual and auditory responses to motion in a sight recovery subject, MM. MM acquired vision in adulthood after becoming blind at age three. Despite severe losses in acuity, MM has no known deficits in his ability to process visual motion and shows normal hMT+ responses to moving dots. However, as a result of being blind early in life, his hMT+ also shows robust cross-modal responses to auditory motion (Saenz et al. 2008). We examined joint tuning for motion direction across visual and auditory stimuli in MM using both multivoxel pattern classification and fMRI adaptation. The direction of auditory

motion could be successfully classified based on the pattern of BOLD responses within bilateral hMT+ to a visual motion stimulus, and vice versa, indicating congruence in architecture between auditory and visual direction motion tuning within hMT+. Furthermore, significant adaptation effects were found in the right hMT+ when using a visual adaptor – responses to auditory motion were weaker when auditory motion was in the same direction as the visual motion adaptor, suggesting shared neuronal tuning across vision and audition. Our results show that in area hMT+ the directionally tuned auditory motion responses induced by early blindness share common architecture with residual visual motion responses.
Bullet points:

S2.3 GEOMETRIC MEAN OF AUDITORY INTERVALS ASSIMILATES VISUAL APPARENT MOTION

Lihan Chen

Peking University, China

Our brain can efficiently extract averaged statistics of various properties of a group of stimuli, known as ensemble coding (perceptual averaging). To date, there has been little evidence of whether ensemble coding of stimuli from one modality could affect the perceptual processing of the stimuli from the other modality. Here we examined how ensemble coding of auditory intervals affects the percept engendered by the imbedded 'Ternus-type', visual apparent motion. Even though the auditory intervals were entirely task-irrelevant and could thus be ignored, we found the mean of the auditory interval to assimilate the subsequent interval between the Ternus visual display frames, causing a systematic bias of perceptual decisions as to the (to-be-reported) form of visual motion perceived: element vs. group motion. Auditory intervals with long means elicited more reports of group motion, whereas auditory intervals with short ensemble means gave rise to dominant percepts of element motion – importantly, regardless of the regularity and variability of the auditory sequence. Furthermore, we found that the ensemble coding operates in the manner of the geometric, rather than the arithmetic, mean for auditory-interval averaging. The internal representation of statistical temporal features of cross-modal events may reflect a general perceptual crossmodal integration underlying complex audio-visual interactions in everyday dynamic situations.
Bullet Points:

S2.4 ADAPTATION REVEALS CONVERGENCE OF AUDITORY AND TACTILE FREQUENCY SIGNALS

Jeff Yau

Baylor College of Medicine, USA

We perceive temporal frequency information by touch and audition. Recent evidence from behavioral, neurophysiological, and neuroimaging studies suggest that touch and audition are closely linked. Findings from multiple psychophysical experiments suggest frequency processing in the somatosensory and auditory systems rely on similar or common neural circuits. We tested this hypothesis using adaptation paradigms in behavioral and neuroimaging experiments. Behavioral responses patterns, recapitulated in in silico experiments, reveal that auditory adaptation induces highly specific improvements in tactile sensitivity. Whole-brain fMRI reveals response signatures consistent with frequency-specific auditory and tactile processing in overlapping peri-Sylvian cortical regions. These results provide strong support for the notion that frequency processing for touch and audition engages shared, supramodal neural circuits.

S2.5 SERIAL DEPENDENCIES IN RAPID STIMULUS SEQUENCES SHOW EVIDENCE FOR ATTRACTIVE AND REPULSIVE ADAPTATION OVER BRIEF TIME-SCALES

David Alais

University of Sydney, Australia

Several recent studies have shown that a rapid form of adaptation occurs between trials in rapid sequences of varying stimuli. Sequential effects often produce positive dependencies (perception biased towards the previous stimulus: similar to priming), contrasting with repulsive aftereffects (negative dependencies) seen after sustained exposure to a single stimulus. Here, a review of very recent work together with new experimental data shows that positive dependencies occur strongly in both spatial and temporal domains, both within and between modalities. Effect sizes can be large, with the previous stimulus accounting for up to a third or more of the current response. These findings suggest a process which stabilises current perception by averaging the recent past to produce the positive dependency. This would be beneficial for any attribute that remains largely stable over time (discounting variability as noise) but not for highly variable attributes where signal variation conveys important information. For variable attributes, conventional 'repulsive' adaptation provides a better mechanism as it is optimized for detecting change. In an experiment that varied the stimulus in two dimensions (one variable attribute, one stable attribute), we found a strong dissociation between adaptation effects: a positive dependency for the stable attribute, and a negative one for the variable attribute. The finding that both positive and negative serial dependencies can operate at the same time on the same stimulus suggests a sophisticated flexibility in sensory adaptation.

S2.6 MODULATION OF ADAPTIVE LOCOMOTOR LEARNING THROUGH MANIPULATION OF OPTIC FLOW

James Finley

University of Southern California, USA

Locomotion is a complex motor behavior that can be modified by sensory information from multiple sources. Somatosensory information provides feedback about the physical interaction between our bodies and the external world, and can be used to adapt our locomotor patterns to account for changes in the environment. Visual information, such as optic flow, influences our perception of self-motion, and previous studies have shown that mismatches between optic flow speed and walking speed can drive changes in stride length and cadence. Here, we explore the interaction between somatosensory information and optic flow during adaptation to walking on a dual-belt treadmill. In this task, participants walk on a treadmill with two belts that move at different speeds. This discrepancy initially causes individuals to walk with steps of unequal length, but following a period of trial-and-error practice, individuals eventually adapt their locomotor pattern to take steps of equal length. We hypothesized that step-to-step changes in optic flow speed would be capable of driving changes in step length symmetry during dual-belt treadmill adaptation. Surprisingly, we found that an Incongruent stimulus, in which optic flow speed was matched to the speed of the swing leg, accelerated the adaptation process. This acceleration was mediated by changes in spatial, but not temporal, features of the walking pattern. These results demonstrate that locomotor adaptation is not a simple error-based process driven solely by the mechanical interaction between the body and environment, but is instead a process that relies on integration of sensory input from multiple sources.

SYMPOSIUM 3: A MULTISENSORY INVESTIGATION OF THE FUNCTIONAL SIGNIFICANCE OF PAIN-RELATED BRAIN RESPONSES: PSYCHOPHYSIOLOGICAL IMPLICATIONS AND METHODOLOGICAL ADVANCES

Friday June 17th 08:30-10:00

Organizer: Li Hu

Introduction

Many research groups have used different functional neuroimaging techniques (e.g., EEG, MEG, fMRI, PET) to investigate the neural basis of pain perception in humans. Even the pain-related brain responses are often considered to represent a unique cerebral signature for pain perception (or a neural "pain signature"), recent findings demonstrated that a fraction of the neuronal activity measured using these neuroimaging techniques in response to transient nociceptive stimuli is likely to be largely unspecific for nociception. Considering that pain, as a conscious experience, is crucial for survival, the understanding of the functional significance of pain-related brain responses is important for both basic research and clinical applications. Therefore, in this symposium, we will discuss our recent findings about the functional significance of pain-related brain responses, and highlight recent advances about the signal processing techniques to understand these brain responses.

S3.1 PAINFUL ISSUES IN PAIN PREDICTION

Li Hu

Institute of Psychology, Chinese Academy of Sciences, China

How perception of pain emerges from neural activity is largely unknown. Identifying a neural "pain signature" and deriving a way to predict perceived pain from brain activity would have enormous basic and clinical implications. Researchers are increasingly turning to functional brain imaging, often applying machine-learning algorithms to infer that pain perception occurred. Yet such sophisticated analyses are fraught with interpretive difficulties. Here we will highlight some common and troublesome problems in the literature, and suggest methods to ensure researchers draw accurate conclusions from their results. Since functional brain imaging is increasingly finding practical applications with real-world consequences, it is critical to interpret brain scans accurately, as decisions based on neural data will only be as good as the science behind them.

S3.2 CROSS-INDIVIDUAL PAIN PREDICTION: IS IT ONLY A MATTER OF METHODS?

Zhiguo Zhang

School of Data and Computer Science, Sun Yan-Sen University, China

The performance of pain prediction based on neural signals, such as EEG and fMRI, is seriously hampered by the substantial inter-individual variability in the pain perception as well as neural signals. Here we will discuss whether advanced machine learning methods can effectively improve the accuracy of cross-individual pain prediction.

S3.3 PRIMARY SENSORY CORTICES CONTAIN DISTINGUISHABLE SPATIAL PATTERNS OF ACTIVITY FOR EACH SENSE

Meng Liang

School of Medical Imaging, Tianjin Medical University, China

Whether primary sensory cortices are essentially multisensory or whether they respond to only one sense is an emerging debate in neuroscience. Using multivariate pattern analysis of fMRI data in humans, we found that simple and isolated stimuli of one sense

elicit distinguishable spatial patterns of neuronal responses, not only in their corresponding primary sensory cortex, but also in other primary sensory cortices. These results prompt a reconsideration of how sensory information is coded in the human brain.

S3.4 DISRUPTED BRAIN CONNECTOME AND ITS CHANGING TREND IN MIGRAINE SUFFERERS

Jixin Liu

School of Life Science and Technology, Xidian University, China

In recent years, neuroimaging has provided new insight into potential mechanisms of migraine and led to a transition from a purely vascular hypothesis of migraine pathophysiology to a CNS theory. There is accumulating evidence showing that long-term migraine alters brain structure and function beyond pain perception by distorting spatial and temporal properties of neural connectivity. The extent of functional reorganization and structural change may follow a distinct pattern in migraine, with the mechanisms driving this long-term restructuring process to unfold over a period of years. Our study attempt to identify the disorganization principles of brain connectome that the brain interacts with long-term headache across time.

S3.5 MULTI-MODALITY SENSORY STIMULI INDUCED TIME-FREQUENCY ELECTROPHYSIOLOGICAL RESPONSES

Weiwei Peng

Faculty of Psychology, Southwest University, China

To progress in our understanding of the neural oscillatory process underlying the perception of sensory stimuli of different modalities, the temporal-spectral-spatial characteristics of time-frequency oscillatory responses to multi-modality sensory stimuli (i.e., auditory, visual, somatosensory, and pain stimuli) will be comprehensively compared, and their relationship with single-trial ratings (intensity score and salience score) will also be discussed.

S3.6 AMPLITUDES AND LATENCIES OF SINGLE-TRIAL LEPS ESTIMATED BY A AN ADAPTIVE TIME ALIGNMENT METHOD

Gan Huang

School of Data and Computer Science, Sun Yan-Sen University, China

Latency jitter is an important issue in many biomedical processing areas. In this talk the amplitudes and latencies of LEPs are estimated by solving a constrained quadratic program problem. The adaptive property of the system derives from iterating and averaging of the data signals and permits a more precise estimation of amplitudes and latencies.

SYMPOSIUM 4: CROSS-MODAL PLASTICITY AND INTEGRATION IN SENSORY RESTORATION BY INVASIVE/NON-INVASIVE APPROACHES (AND THEIR POTENTIAL COMBINATION): FROM BASIC SCIENCE TO REHAB

Friday June 17th 12:55-14:35

Organizers: Amir Amedi & Benedetta Heimlera

Introduction

Advances in biotechnology are quite astonishing that it seems that in the next decade or two sensory restoration techniques will become more and more widespread (e.g. today there are 300,000 cochlear implants with rapid expected growth even for the elderly; visual prostheses will follow but with a slower adoption rates). On the other hand the performance of such patients in some domains is far from being optimal (to say the least). Thus, there is a real need to formulate rehabilitative approaches and be able to predict their success from the available basic science evidence, especially since the behavioral outcomes of the existing approaches have been so far quite disappointing to different degrees in visual, auditory and somatosensory restoration. At the same time while this type of clinical work proved itself over and over in the past as being an amazing model to answer crucial basic science questions regarding the organization of the sensory brain, pointing to the revolutionary claim that the brain works as a task-machine rather than as a sensory-machine (for reviews see Heimler et al 2016 Curr Opin Neurobiol; Hannagan et al 2015 Trends Cogn Sci; Heimler et al 2014 Neurosci; Ricciardi et al 2013 Neurosci Biobehav Rev; Collignon et al 2009 Exp Brain Res).

In this symposium we will address both rehab and basic science questions. In terms of rehab – we aim at challenging the two most widespread assumptions that have been driven all rehabilitative approaches until now: 1- the notion that cross-modal plasticity, i.e. the recruitment of the deprived sensory cortex by the remaining senses, is a negative predictor of sensory restoration outcomes (Campbell & Sharma, 2016 Plos One; Kral & Sharma, 2012 Trends Neurosci; Lee et al., 2001 Nature). And 2- that in order to avoid the emergence of cross-modal plasticity, rehabilitative approaches need to be unisensory, i.e. relying on the sole restored sensory modality, rather than multisensory, i.e. pairing the newly restored sensory modality with one –or more- intact and familiar senses (Hogan et al., 2008 Deafness & Education International; Fu et al., 2008 Hearing research; Ingvalson & Wang, 2013 Frontiers in Psychology). In terms of basic science we plan to address fundamental questions regarding the effects of multisensory stimulations on a variety of computational tasks including basic computational tasks such as motion, as well as more higher-level ones such as object recognition, numerical/letter recognitions and spatial navigation.

In this symposium will team-up several key labs that will contribute to this multidisciplinary symposium with the following topics / titles: (1) Cochlear implants (CIs) as the best model for improving sensory restoration outcomes (Heimler, Buchs and Izhar) (2) Novel multisensory audio-visual training in cochlear implant patients (Wang & Amedi) (3) The effects of visual restoration on the blind brain: The cataract model (Collingnon) (4) New venue in visual restoration: pairing vision with Sensory Substitution Devices (Meidenbuam & Daniel Robert Chebat)

S4.1 COCHLEAR IMPLANTS (CIS) AS THE BEST MODEL FOR IMPROVING SENSORY RESTORATION OUTCOMES

Benedetta Heimler

Hebrew University of Jerusalem, Israel

We will present the state of-the-art regarding research on sensory restoration/rehabilitation with a specific focus on cochlear implants. They will also introduce novel approaches to sensory restoration focusing on multisensory rather than unisensory training programs (Heimler et al 2016 Curr Opin Neurobiol).

S4.2 MOPPET: A NOVEL AUDITORY TRAINING PLATFORM TO TEACH MUSIC TO CHILDREN WITH COCHLEAR IMPLANTS

Ye Wang
National University of Singapore, Singapore

Children with cochlear implants (CI) have difficulty appreciating music because of the impairment of their hearing and the limitations of current devices. This impairment is particularly acute in pitch perception and timbre recognition. These limitations bring multiple challenges to their everyday life, especially in a world that is saturated with music. Research shows that music training can improve music perception and appreciation for CI users. However, compared to the multiple computer-assisted solutions for language training, there are few systems that exploit the benefits of computer technologies to facilitate music training of children with cochlear implants. We developed SECCIMA, a predecessor of MOPPET, for music training of children with CI. In this talk I will share our experience in developing such a system as well as the future directions.

S4.3 MULTISENSORY AUDIO-VISUAL-TACTILE TRAINING IN COCHLEAR IMPLANT PATIENTS

Amir Amedi

Hebrew University of Jerusalem, Israel

We will present novel data on auditory restoration that will compare more directly the benefits of multisensory versus unisensory training approach. In particular they will show results coming from children fitted with a CI on the recovery of basic auditory features (e.g., pitch; timbre) as a first step towards a more satisfactory recovery of musical sounds (Xinxi et al., 2014 ACM Trans Multimedia Comput Commun Appl; Zhou et al., 2011 ACM CHI). They will innovatively compare training outcomes as a result of unisensory (auditory-only training) (Zhou et al. 2012 ACM Multimedia Conference) versus multisensory (audio-visual) training programs pairing the auditory stimulation with auditory-to-visual Sensory Substitution Devices (SSDs).

S4.4 THE EFFECTS OF VISUAL RESTORATION ON THE BLIND BRAIN: THE CATARACT MODEL

Olivier Collignon

Neural Rehabilitation Engineering Laboratory, Université Catholique de Louvain, Brussels, Belgium; Center for Mind/Brain Sciences (CIMeC), University of Trento, Italy

Prof. Collignon will present novel data on cataract patients showing the effects of transient visual-deprivation at birth elicited by congenital cataracts (Dormal et al. 2015 J Neurophysiol; Collignon et al 2016 Curr Biol). He will discuss persistent cross-modal plasticity effects in the reafferented visual cortex by different types of auditory stimuli and he will also discuss the neural networks involved in this type of plasticity.

S4.5 RECRUITING THE VISUAL NEURAL NAVIGATION NETWORK FOR AUDITORY NAVIGATION FOLLOWING LIFELONG AND TEMPORARY VISUAL-DEPRIVATION

Shachar Maidenbaum

Hebrew University of Jerusalem, Israel

We will discuss new evidence regarding the effects of visual restoration on the cognitive and neural mechanisms of the blind brain, together with novel data suggesting the benefit of pairing SSD to the newly restored visual input (Shinazi et al 2016 WIREs).

SYMPOSIUM 5: PRACTICE OF SENSES AND TECHNOLOGY (SPONSORED BY HENGYUANXIANG GROUP)

Friday June 17th 16:00-18:15

Chair: Lihan Chen

S5.1 IMPACT OF SYNESTHESIA AND CROSS-SENSORY INTERACTIONS ON MULTISENSORY DESIGN OF BRANDS AND PRODUCTS.

Michael Haverkamp

Expert for Cross-Sensory Harmonization, Ford Product Development Centre Cologne, Germany

Configuration of products and brand attributes is a highly creative process within which perception plays a major role. A meaningful configuration can only be found if various senses are involved. This enables intuitive communication of product and brand features to the customer. By means of a multisensory design, plausibility and emotional involvement can be achieved. Visual, auditory, tactile and even olfactory and gustatory contributions interact with each other during processes of cross-sensory integration. Therefore, a multi-sensory design requires systematic alignment of (perceived) features, which refer to the specific senses. While perception is a multi-sensory phenomenon, design processes focused on single senses show limited effectivity. As an example, surfaces of the vehicle interior need to provide tactile features and touch sounds which are consistent with the visual appearance. During the last decades, perceptual phenomena of synesthesia have gained increasing interest. The strictly individual nature of synesthesia causes unique phenomena. In contrast, the development of products and brands requires approaches which are intuitively understood by a broad community. A view on synesthetic perception offers new perspectives and may enhance creativity. The presentation will explain the most important approaches of multi-sensory, cross-sensory and synesthetic design. A variety of applications illustrate the benefit, including aesthetic harmonization of materials and human machine interaction.

S5.2 USER EXPERIENCE DRIVEN INNOVATION: PRACTICES IN HEALTH IT

Ying Liu

User Experience Research Scientist, Health Strategies and Solutions Group, Intel

Innovation is a key differentiator for companies and startups to grow their business. Experience driven innovation is one of the key approaches to drive new products or platforms creations. In the presentation, Ying will talk about experience driven new product or platform creation and how that can help to trigger new markets or businesses. The user experience driven innovation approach start from understand an ecosystem including key stakeholders and end users, around the key areas for improvement, new products or platforms were design to meet the new requirements or solve the pains. A few design cases will be explained in the presentation too.

S5.3 MULTISENSORY INTEGRATION AND VIRTUAL REALITY

Xiaoou Li

Sales Manager of China, WorldViz LLC

Virtual reality is one of the most eye catching cutting edge technology. Generally, it consists of 3D display (3D head-mounted display or 3D projection), motion tracking system and virtual reality engine. Immersion and Interactivity are the most important features for this technology by combining 3D display and motion tracking system. It brings users a sense of presense filtered through real-time

surrounding visual, proprioceptive, acoustic -multi-sensory immersion. In order to create a high-fidelity virtual environment, all sorts of virtual reality hardware must take human factors into account. Multi-sensory research provides the foundation and rich references for virtual reality development.

S5.4 SMELL AND EMOTION

Linda Li

Givaudan Fragrances (Shanghai) Ltd

Everyone knows what an emotion is, until asked to give a definition. We outline some of the learnings taken from the literature to develop a definition of emotions and moods, and have expanded this definition into a model which describes the different elements of an emotional experience. Our every day experiences tell us that there is a powerful link between our sense of smell and our emotions. Scientific research has also confirmed this connection between smell and emotion which will be explored further on the next few pages. The olfactory system is one of our 5 sensory systems (olfaction, taste, vision, audition, touch), is highly conserved (similar) over different animals. Information about the incoming odorants is first converted from a chemical signal into an electrical signal in the receptors in the nose. After the odour is interpreted by the primary olfactive cortex, the signals are then sent on to other areas of the brain such as the orbitofrontal cortex and the hypothalamus. The hypothalamus allows olfactory signals to be linked with physiological and endocrine (hormone) responses. The orbitofrontal cortex receives inputs from all the major sensory systems and is effective at interpreting this information together to create a multisensory experience, as well as being involved in emotion, reward and decision-making processing. Besides consumer test methods, EEG and fMRI are common scientific techniques used for studying the linkage of smell and emotion. Fragrances with good smell can deliver many positive emotion benefits, improve sleep quality and memory. Givaudan has studied the emotion and fragrances for many year and has developed fragrances for evoking positive emotion.

S5.5 HOW REAL IS REAL: VISUALIZING GLARE EFFECTS IN A VIRTUAL ENVIRONMENT

Shuguang Kuai

School of Psychology and Cognitive Science, East China Normal University

Creating close-to-real virtual experience is critical for applications of virtual reality. Although visualizing lighting is successfully achieved in technical aspects, it is challenging to duplicate lighting experience in virtual environments due to narrow ranges of screen luminance (0-300 cd/m^2) compared with very wider luminance range in a real environment which could be over 10000 cd/m^2. To create a perceptually corrected lighting experience in virtual environments requires understanding human visual perception in virtual and real environment as well. In this study, we explore approaches to model glare perception in virtual environments by utilizing characteristics of contrast perception in the human visual system. We found that a gradually decreasing surrounding faint makes a center stimulus looks like a self-illuminated light source, which generate artificial glare perception. We measured the critical bands of surrounding faint inducing the glare perception using psychophysical experiments. Our further analysis indicates that artificial glare perceptions are built up based on human experience in perceiving lighting on pictures. Our study could help improve visual reality of lighting experience in virtual environments.

SYMPOSIUM 6: ADDITIONAL CROSS-MODAL SENSATIONS FROM PRIVATE PERCEPTIONS TO SHARED ASSOCIATIONS

Saturday June 18th 08:30-10:10

Organizer: Romke Rouw

Introduction

In constructing percepts and planning actions, our ability to make sense of a multitude of sensory inputs is characterized by a remarkable vividness and richness. This ability requires neural mechanisms for multisensory integration. An extreme case of such multi-sensory event is when a particular event will evoke an additional sensation in another modality. Despite the absence of a corresponding stimulus, the resulting sensation is vivid, specific and has a sensory/perceptual nature. In this symposium, we will present different cases of this type of extraordinary sensations. We also present cases, where mechanisms of multisensory integration create associations at a subconscious, abstract and operational level. These cross-modal correspondences can influence our behavior even if we are not aware of it (e.g. many people find particular colors more 'logical' fit to particular letters, but do not actually 'see' those colors). We present different categories of extraordinary additional cross-modal sensations: associating a color with a letter in synesthetes versus non-synesthetes, exploring visual or spatial sensations in the blind during training with a sensory substitution device; and experiencing a disproportionate emotional response to particular sounds (Misophonia and ASMR).

In this symposium, we present three different categories of additional cross-modal sensations. First, we present the distinction between synesthetic versus non-synesthetic letter-to-color associations. In synesthesia, a particular sensation will evoke another, seemingly unrelated, sensation. A common type of synesthesia is grapheme-color synesthesia, where a particular letter or number will evoke a particular color. Synesthetic experiences are specific, consistent, automatic (it does not take conscious effort to retrieve the colors), idiosyncratic (each synesthete has his/her own set of inducer-to-concurrent sensations) and are experienced as perceptual sensations. Remarkable, when non-synesthetes are asked to match colors to letters, they show similar patterns of behaviors even though they have no conscious letter-to-color experiences. Furthermore, these patterns can be found across different languages and cultures.

At the end of the symposium there is time for a panel discussion (speakers & audience). What explains the distinction between private cross-modal sensations (such as in synesthesia, misophonia, or blind people that have visual sensations), and the shared amodal cross-modal associations (such as the letter-to-color correspondences in non-synesthetes, or other cross-modal unconscious associations influencing behavior in general population)? Are there different mechanisms, operating in different groups and under different rules? Or is there a 'scale' of behaviors, with on the one end the type of cross-modal associations that are present in almost all people, and on the other end of the scale the exceptional cases of these same mechanisms, leading to vivid, private, sensory (and or emotional) responses?

S6.1 INTRINSIC ASSOCIATIONS IN NON-SYNESTHETIC POPULATION BETWEEN SOUND AND COLOR

Chai-Youn Kim, Hyun-Woong Kim & Hosung Nam

Department of Psychology, Korea University, Korea

Previous studies on synesthesia have suggested non-random association between sounds of linguistic units and colors (Asano & Yokosawa, 2011; 2012; Shin & Kim, 2014). A work in our group also showed that graphemes sharing phonetic rules–i.e., the place and the manner of articulation –tend to induce similar synesthetic colors across multiple languages (Kang et al., ASSC 2014). In the present study, we investigated whether phonetic properties are associated with colors in a specific manner even when other visual and linguistic features of graphemes are removed. In Experiment 1, we employed Haskins Laboratories articulatory synthesizer to generate vowel sounds as stimuli by systematically manipulating voice gender and tongue body position (‘frontness’ and ‘height’). In Experiment 2, we synthesized consonant-vowel (CV) sounds by manipulating the organ of constriction (lips, tongue tip, tongue body),

constriction degree, glottal gestures, and velum gestures. Participants including both synesthetes and non-synesthetes were tested with a modified version of the standardized color-matching procedure (Eagleman et al., 2007) to choose a color after hearing each sound. Results from Experiment 1 showed difference in both saturation and value of matched colors between male and female voices. In addition, HSV values and CIE Lab color coordinates of matched colors showed systematic variation along the two axes of the tongue body position. Results from Experiment 2 showed that CV sounds with the same glottal (e.g., /peh/, /teh/, /keh/) or the same velum (e.g., /me/, /ne/, /nge/) gestures tended to be associated with more similar colors than others. Taken together, these results imply that the association between phonetic features and colors is not random, and this synesthetic association is extended to individuals without synesthesia.

S6.2 MISOPHONIA, ASMR & SYNESTHESIA: 'SPECIAL CASES' OR NORMAL CROSS-MODAL INTEGRATION?

Romke Rouw, Miren Edelstein

Department of Psychology, Brain & Cognition, University of Amsterdam, Amsterdam, Netherlands

In this presentation we present conditions of 'seeing' things that aren't really there, and 'hearing' that is relatively unrelated to the physical properties of the auditory stimulus. These conditions are in contrast with the traditional story of how our sensations are created by processing information acquired through our senses. Furthermore, the sensations are not present as a subpart of characteristics of a psychiatric disease. Three conditions are presented (Misophonia, ASMR and synesthesia) were a stimulus in one modality will evoke a seemingly unrelated and disproportional response in another modality. The conditions are not part of a neurological, psychiatric or psychological disease. For people with these conditions additional (cross-modal) sensations are part of normal daily life. While in synesthesia mostly perceptual sensations are evoked, in misophonia (strong aversive responses to particular sounds) and ASMR (strong relaxing responses to particular sounds) the additional sensations have a strong emotional content. Do these additional sensations reflect processes that are qualitatively 'different', or are they merely at the extreme end of normal cross-modal integration? Should the experiences be explained as presenting a stronger case of (sensory or emotional) awareness?? We also discuss if structural or functional brain properties reflect the 'special' status of these extraordinary sensations. At the end of the presentation, a short introduction of 'learning' paradigms is presented. In these paradigms, participants are trained to develop synesthetic-like experiences. To what extend can these paradigms induce 'real' phenomenological experiences? And how could these types of training paradigms be put to use? This also introduces questions relevant for training paradigms with sensory substitution devices, as discussed in the next presentation.

S6.3 A CASE STUDY OF SKILL DEVELOPMENT AND CHANGES IN PHENOMENOLOGY OF BLIND USERS OF A SENSORY SUBSTITUTION DEVICE.

Kate Backhouse[1], Romke Rouw[2] & Amir Amedi[1]

[1]Hebrew University of Jerusalem, Israel; [2]University of Amsterdam, Amsterdam, Netherlands

Graphical virtual environments are currently far from accessible to blind users as their content is mostly visual. This is especially unfortunate as these environments hold great potential for this population for purposes such as safe orientation, education, and entertainment. Previous tools have increased accessibility but there is still a long way to go. Visual-to-audio Sensory-Substitution-Devices (SSDs) can increase accessibility generically by sonifying on-screen content regardless of the specific environment and offer increased accessibility without the use of expensive dedicated peripherals like electrode/vibrator arrays. Using SSDs virtually utilizes similar skills as when using them in the real world, enabling both training on the device and training on environments virtually before real-world visits. This could enable more complex, standardized and autonomous SSD training and new insights into multisensory

interaction and the visually-deprived brain. However, whether congenitally blind users, who have never experienced virtual environments, will be able to use this information for successful perception and interaction within them is currently unclear.
In a pilot study we explored skill development and changes in phenomenology during training program with SSD. There are indications that with minimal training participants can make great progress in using SSDs, both in their skill ability and in changes of phenomenology. Further exploring the boundaries of these types of training paradigms, color sorting experiments (in the scanner) using sounds are presented. These lines of research raise new questions and possibilities for future research in both fields. In the future this type of structured training coupled with extensive phenomenology testing and neuroimaging may be the key to understanding sensory awareness.

S6.4 BLIND IN A VIRTUAL WORLD: PERCEPTION, IMMERSION AND NAVIGATION USING VISUAL-TO-AUDITORY SENSORY-SUBSTITUTION DEVICES

Shachar Maidenbaum, Galit Buchs & Amir Amedi

Department of Cognitive Science, Faculty of Humanities, Hebrew University of Jerusalem, Israel

Graphical virtual environments are currently far from accessible to blind users as their content is mostly visual. This is especially unfortunate as these environments hold great potential for this population for purposes such as safe orientation, education, and entertainment. Previous tools have increased accessibility but there is still a long way to go. Visual-to-audio Sensory-Substitution-Devices (SSDs) can increase accessibility generically by sonifying on-screen content regardless of the specific environment and offer increased accessibility without the use of expensive dedicated peripherals like electrode/vibrator arrays. Using SSDs virtually utilizes similar skills as when using them in the real world, enabling both training on the device and training on environments virtually before real-world visits. This could enable more complex, standardized and autonomous SSD training and new insights into multisensory interaction and the visually-deprived brain. However, whether congenitally blind users, who have never experienced virtual environments, will be able to use this information for successful perception and interaction within them is currently unclear.
We tested this using the EyeMusic SSD, which conveys whole-scene visual information, to perform virtual tasks otherwise impossible without vision. Congenitally blind users had to navigate virtual environments and find doors, differentiate between them based on their features (Experiment1:task1) and surroundings (Experiment1:task2) and walk through them; these tasks were accomplished with a 95% and 97% success rate, respectively.
We further explored the reactions of congenitally blind users during their first interaction with a more complex virtual environment than in the previous tasks – walking down a virtual street, recognizing different features of houses and trees, navigating to cross-walks, etc. Users reacted enthusiastically and reported feeling immersed within the environment. They highlighted the potential usefulness of such environments for understanding what visual scenes are supposed to look like and their potential for complex training and suggested many future environments they wished to experience.
Finally, we comparatively discuss these results with real world behavior using SSDs, and compare the views of both users and trainers on different types of training

S6.5 CROSS-CULTURAL DIFFERENCES IN COLOUR-FLAVOUR ASSOCIATIONS

Xiaoang Wan[1] & Charles Spence[2]

[1]Department of Psychology, Tsinghua University; [2]Crossmodal Research Laboratory, Department of Experimental Psychology, University of Oxford

Here, we review a recent series of published studies examining the crossmodal correspondences observed in the case of beverages, food, pharmaceutical pill, and packaging. Taken together, the findings reveal how the meaning that people attach to colour can influence their perception of and the expectation concerning flavour, and how a given colour can take on different meanings as a function of the context. We also illustrate how online testing was used to examine the meaning of colour and the influence of contextual factors in 8 countries across 4 continents. The observed cross-cultural differences in colour-flavour associations are too complex and subtle to use the common differentiation into Western/ Eastern cultures to interpret. These findings therefore highlight the impact of cultural background on crossmodal correspondences, and raise a number of interesting questions regarding the neural mechanisms that underlie them.

TALK SESSION1: BODY REPRESENTATION AND SELF

Wednesday June 15th 17:50 - 18:35

Chair: Laurence Harris

T1.1 TACTILE AND VISUAL PROCESSING DURING THE RUBBER HAND ILLUSION - AN EVOKED POTENTIALS STUDY

Isa Shashikala Rao, Christoph Kayser

Centre for Cognitive Neuroimaging, Institute of Neuroscience and Psychology, University of Glasgow, UK

The rubber hand illusion (RHI) is used to induce the illusory feeling of ownership over a rubber hand through congruent multisensory stimulation. Thus, it can grant insights into how the brain resolves situations of conflicting multisensory information regarding the body's position. To examine how dynamic changes in bodily consciousness caused by this resolve impact on sensory perception and multisensory integration we acquired multichannel EEG of 13 participants during a modified RHI paradigm. Using a vibration pad on the participant's hand and an LED of similar size on the rubber hand, we acquired evoked potentials registered to the onset of visual and tactile stimulation during four conditions. Visual and tactile stimulation was either synchronous with an anatomically congruent (illusion condition) or incongruent (no illusion condition) placed rubber hand, or unisensory in the absence of the rubber hand. In addition, visual and tactile unisensory conditions were used to identify time points and electrodes of interest. Significant differences emerged in fronto-central areas in the tactile P200 component with the illusion condition showing an amplified response compared to the no illusion condition. In contrast to this, the visual P1 component showed a reduced response in the illusion condition compared to the no illusion condition. These findings suggest that changes in bodily consciousness affect evoked responses to visual and tactile stimuli in distinct ways. Our results also show that more specific control conditions are needed to rule out potential confounds by attention and by the position of the visual stimulus in relation to the body.

T1.2 THE LANDMARK LOCALIZATION TASK AND DOMAIN-GENERAL BIASES: EVIDENCE AGAINST A DISTORTED BODY MODEL HYPOTHESIS

Jared Medina, Caitlin Duckett

University of Delaware, USA

Previous research has proposed the existence of a distorted body model[1]; judgments of the location of hand landmarks without viewing the hand are characterized by a wide hand and shortened fingers. We propose an alternative hypothesis in which this "distorted body model" is caused by domain-general biases. In three experiments, we asked individuals to localize the metacarpophalangeal joints (knuckles) of their left hand, located under an occluding board. We then used a lag-1 analysis to find predictors of the perceived distance between any two consecutive landmark localization judgments. Along the mediolateral hand axis, judgments for consecutive stimuli were perceived as wider when consecutive judgments were closer (e.g. index-middle knuckle) versus farther in space (e.g. index-pinky). Controlling for this, we surprisingly found no evidence for distortions in perceived hand width. Furthermore, judgments to/from the thumb knuckle were consistently perceived as shorter along the distal-proximal axis. We hypothesized that wider localization judgments for closer stimuli may be caused by domain-general biases. Next, we presented additional subjects with a landmark task in which they reported the remembered location, not of hand landmarks, but of five dots below an occluding board. Manipulating between dot distance across blocks (from ½ to double the average hand knuckle distance), the perceived between dot distance was substantially wider for the hand-sized array, with increased widening for more compact

versus spaced arrays. We propose that previous results may not be consistent with a distorted body model hypothesis, and discuss potential domain-general mechanisms that can explain these effects.

T1.3 POSTURAL MODULATION BY (UN)EMBODIED PROSTHETIC ARM

Shu Imaizumi[1,2,3], Tomohisa Asai[2], & Shinichi Koyama[1]

[1] Chiba University, Chiba, Japan; [2] NTT Communication Science Laboratories, Kanagawa, Japan;[3] Japan Society for the Promotion of Science, Tokyo, Japan

Senses of body ownership (“this arm belongs to me”) and agency (“I am controlling this arm”), constituting the sense of self, stem from the sensorimotor system. External objects (e.g., prostheses) can be integrated into the sensorimotor system due to long-term use, and recognized as one's own body or effector. We examined how an (un)embodied prosthetic arm modulates whole-body (postural) control, and assessed the components of embodiment of the prosthetic arm. Nine male unilateral upper-limb amputees participated. Four frequently used their prosthetic arm, while the others rarely used it. Postural sway was measured during quiet standing with or without the prosthesis. The frequent users showed greater sway when they removed the prosthesis, while the rare users showed greater sway when they fitted the prosthesis. Frequent users reported greater everyday feelings of postural stabilization by prosthesis and a larger sense of agency over the prosthesis. A follow-up experiment with age- and sex-matched healthy controls confirmed that these postural modulations by a prosthetic arm were not simply due to abnormal postural control in the amputees. We suggest that an embodied prosthetic arm maintains amputees’ postural control while an unembodied arm perturbs it, and prosthetic embodiment is likely to involve the sense of agency rather than ownership.

TALK SESSION 2: LEARNING AND PLASTICITY OF MULTISENSORY PROCESSING

Wednesday June 15th 18:35 – 19:20

Chair: Jean Vroomen

T2.1 CONNECT THE DOTS: BRAILLE LEARNING IN SIGHTED IMPROVES HAPTIC OBJECT RECOGNITION

Furat AlAhmed, Christian Wallraven

Korea University, Republic Of Korea

Tactile stimulation has been proven to increase haptic performance in different types of perceptual tasks. Results have demonstrated, for example, a positive effect on haptic acuity and object recognition as a result of simple, electric stimulation to the fingers. To date, not much is known about how tactile stimulation that people may be exposed to as part of everyday learning activities may play a role in haptic performance. Here, we test the impact of English Braille learning as a means of providing tactile stimulation on different types of haptic tasks. Eleven sighted undergraduate students were recruited from Korea University to participate in a 4-week program of English Braille learning. In addition to the (successful) Braille learning, we conducted three haptic control tasks before and after the training. In a difficult object similarity-rating task, we found a significant improvement after Braille training, whereas no improvement was found in a haptic pattern matching task or a tactile roughness rating task. Our results confirm that Braille training has a positive impact on an unrelated haptic perceptual task. Such training may also relate to findings in which blind people have improved haptic perception compared to sighted, and may indicate that regular tactile stimulation would even provide the sighted with a more efficient multisensory represent

T2.2 LONG-TERM MUSICAL TRAINING ALTERS THE INTERACTION BETWEEN FRAMES OF REFERENCE

Simon P. Landry; François Champoux

Université de Montréal, Canada

Long-term musical training is an enriched multisensory training environment. It alters sensory substrates and abilities, and has effects on multisensory integration. However, no study has investigated the effects of this multisensory training on sensory frames of reference. The crossed arm temporal order judgement (TOJ) and frame and rod (F&R) tasks are tasks used to measure the ability to integrate sensory frames of reference. These tasks measure the effect of conflicting frame of reference information from tactile and visual input, respectively. In this study, we investigated the effect of musical training on tactile and visual frames of references using a TOJ and F&R task. 14 musicians and 14 controls were recruited. A TOJ task was used in which a conflict is induced between allocentric and egocentric response criteria by crossing the arms. The two groups' average proportion of correct responses (PCD) between crossed and uncrossed postures was compared. The F&R task was used to measure the impact of visual information on subjective direction of gravity. The effect of a visual frame on subjective direction of gravity was compared for both groups. Results from the TOJ task revealed a significant group difference between PCD scores. The performed analysis for the F&R task did not reveal a significant difference between groups. These results suggest that long-term musical training alters the weighing egocentric and allocentric for tactile, but not visual input. Musical training appears to place great importance on tactile information and limb position, thus enhancing the egocentric frame of reference for tactile input.

T2.3 COMPENSATORY RECOVERY AFTER MULTISENSORY STIMULATION IN PATIENTS WITH VISUAL FIELD DEFECTS: BEHAVIORAL AND NEUROPHYSIOLOGICAL COMPONENTS

Paolo Antonino Grasso[1], Caterina Bertini[1], Lisa Cipolotti[2], Elisabetta Làdavas[1]

[1] Department of Psychology - University of Bologna, Italy; [2] National Hospital for Neurology and Neurosurgery, University College London, UK

Patients with visual field defects (VFD) have shown preserved multisensory integrative abilities in the blind field (i.e., crossmodal blindsight), likely subserved by the spared retino-colliculo-dorsal pathway. Accordingly, audio-visual integrative mechanisms could be used to increase the functionality of the spared circuit and might represent an important tool for the rehabilitation of VFD. This study tested this hypothesis, investigating whether exposure to systematic audio-visual stimulation could induce long-lasting visual improvements in patients with VFD. Ten patients with chronic VFD were exposed to audio-visual training (4 hours/daily, over 2 weeks). Behavioral, oculomotor and electroencephalography (EEG) measures were recorded during several visual tasks before and after training. After training, improvements in visual search, visual detection, self-perceived disability in daily life activities and oculomotor parameters were found, suggesting the implementation of effective visual exploration strategies. At the electrophysiological level, after training, patients showed a significant reduction of the P3 amplitude in response to stimuli presented in the intact field, reflecting a reduction in attentional resources allocated to the intact visual field, which might co-occur with a shift of spatial attention towards the blind field. More interestingly, both the behavioral and the electrophysiological changes observed after training were stable at a follow-up session (on average, 8 months after training), suggesting long-term effects of multisensory audio-visual training. These long-lasting effects seem to be subserved by the spared retino-colliculo-dorsal pathway, promoting orienting responses towards the blind field, able to both compensate for the visual field loss and concurrently attenuate visual attention towards the intact field.

TALK SESSION 3: DYNAMIC SPATIAL REPRESENTATION AND HUMAN PERFORMANCE

Thursday June 16th 14:50-15:50

Chair: Maria Concetta Morrone

T3.1 INTEGRATION OF VISUAL AND TACTILE INFORMATION IN PROCESSING OF SELF-MOTION

Jan Churan, Johannes Paul, Frank Bremmer

Department of Neurophysics, University of Marburg, Germany

During locomotion in a natural environment, various sensory signals can be used to determine critical parameters of self-motion. Visual and vestibular signals have been shown to contribute to a precise representation of heading. The role of tactile flow has not yet been determined. We tested the ability of human subjects to utilize visual and tactile information to accurately reproduce a simulated traveled distance. In a first set of trials, subjects first experienced a bi-modal simulated forward translation. We found that the subjects were able to reproduce distances based on the information of each single modality with similar accuracy and precision. With feedback from both modalities, accuracy increased slightly but less than predicted by optimal integration. In a second set of experiments we investigated an effect of rescaling, i.e. a 25% increase or decrease of tactile flow, which were both unnoticed by our subjects. We found a significant effect of rescaling on the reproduced distance suggesting that information of the two sensory modalities was indeed integrated. Interestingly, when we switched the polarity of the tactile stimulus in that slow tactile motion was associated with fast visual motion and vice versa, we found no effect of rescaling. Accordingly, in this case tactile information was not integrated with visual information. We conclude that for a successful integration of sensory information from different modalities, these signals not only have to be informative, but also ecologically congruent. This finding is in line with neurophysiological data from the animal model, i.e. the macaque monkey.

T3.2 THE EFFECTS OF TEMPORAL AND SPATIAL RELIABILITY ON MULTISENSORY AUDIOVISUAL INTEGRATION

Qi Li

School of Computer Science and Technology, Changchun University of Science and Technology, Changchun 130022, China

We are bombarded with information from multiple sensory organs during our everyday life. Our attention system enables a focus on task-relevant information while ignoring irrelevant information. However, task-irrelevant information cannot be completely ignored because humans must constantly monitor their environments. Several behavioral studies have shown that visual perception is enhanced when accompanied by task-irrelevant auditory signals. Our perceptual system can implicitly learn the relationship between the task-irrelevant auditory and visual signals and provide some available information for visual perception. And the behavioral facilitation of sound on visual perception depends on the reliability of information within audiovisual signals. The temporal and spatial factors are two fundamental properties that facilitate the integration of audiovisual stimuli into a unified perception. A strong multisensory integration effect is obtained when visual and auditory stimuli are presented in close spatial and temporal proximity. We used behavioral, event-related potentials (ERPs) and functional magnetic resonance imaging (fMRI) measures to investigate the underlying neural mechanism of temporal and spatial reliability of sound on crossmodal facilitation of visual discrimination. Our results showed that the reliable spatiotemporal relationships within the audiovisual stimuli enhance the linking of auditory and visual stimuli. The temporal linking and spatial linking of auditory and visual stimulus are distinctive patterns of processing in human brain. The bilateral lateral occipital complex (LOC) is particularly modulated by reliable temporal relationships within audiovisual stimuli. In addition, our results verified that auditory behavioral facilitation of visual target discrimination results from late-stage cognitive processes rather than early-stage sensory processes.

T3.3 SPATIAL CHANGE IN MULTISENSORY DISTRACTORS IMPACT ON SPATIAL AND VERBAL SHORT-TERM MEMORY PERFORMANCE

Erik Marsja[1], John Everett Marsh[2], Gregory Neely[1], Patrik Hansson[1], Jessica Körning-Ljungberg[1]

[1]Umeå University, Sweden; [2]University of Central Lancashire, UK

Unexpected changes (known as *deviant* sounds) in a repetitive stream of *standard* sounds are known to prolong responses in visual categorization tasks (Parmentier, 2014) and disrupt short-term memory (Hughes, Vachon, & Jones, 2005; 2007). While this *deviation effect*, has been studied extensively, unexpected changes in multisensory irrelevant stimuli have yet to be explored. A further issue is whether a spatial change in either tactile, auditory, or in both modalities simultaneously, affects verbal and spatial short-term memory similarly. We explored how spatial and verbal memory performance were affected by a spatial change unexpectedly presented in a multisensory stream consisting of task-irrelevant vibrations and sounds. The sounds were presented from headphones and the vibrations from coin-like vibrating motors strapped to the upper arms of the participants. In the majority of trials (approximately 80%) the multisensory stream was presented on one side of the body whereas on deviant trials the irrelevant stimuli changed to the other side of the body. Preliminarily results suggest that a spatial change in a multisensory stream of irrelevant stimuli affects short-term memory performance both the spatial and verbal domains similarly. We conclude by discussing the results in the framework of multisensory views of short-term memory and attention (e.g., Cowan's, 1988; 1995) and the predictive coding framework (e.g., Talsma, 2015).

T3.4 AUDIOVISUAL DISTANCE PERCEPTION: CUE INTERACTIONS AND CAUSAL INFERENCE

Catarina Mendonça

Aalto University, Finland

The localization of visual and auditory events in distance, when presented simultaneously, has only been sparsely studied. We presented realistic stimuli of a male playing an electric piano at several distances, ranging from 1 to 10 m from the observer. Visual and auditory cues were either matching or mismatching in space. Subjects were asked to report where in distance each stimulus was perceived. It was found that the estimation of visual distance is little affected by concomitant auditory cues, but the estimation of auditory distance is affected by visual cues when both cues are in close proximity. Several multisensory models were tested, including sensory dominance, no interaction, mandatory integration, and Bayesian causal inference. Bayesian causal inference explains the data better.

TALK SESSION 4: ILLUSORY TIMING AND PREDICTION IN MULTISENSORY RESEARCH

Thursday June 16th 16:00-17:15

Chair: David Alais

T4.1 CROSSMODAL MIXED DURATION REPRODUCTION FAVORS AMODAL PRIOR

Xuelian Zang[12], Zhuanghua Shi[1], Hermann J. Müller[13]

[1]Experimental Psychology, Department of Psychology, LMU Munich, Germany; [2]College of Psychology and Sociology, Shenzhen University, China; [3]Department of Psychological Science, Birkbeck College, University of London, London, UK

To cope with noisy and overwhelming amount of sensory inputs, our brain utilizes contextual prior knowledge acquired in the past to improve the reliability of sensory estimation (Jazayeri & Shadlen, 2010; Shi, Church, & Meck, 2013). However, incorporating prior

information could also engender systematical biases, such as the central tendency effect. Previous studies on the central tendency effect in magnitude estimation so far only concerned prior knowledge of unimodal information. It is still an open question whether modality-specific prior information are used in a crossmodal mixed magnitude estimation. To investigate this, we designed three experiments on auditory and visual mixed duration reproduction, with short (600-1000ms) and long (800-1200ms) duration sets randomly assigned to auditory or visual stimuli in the first half of the experiment, and reversed in the second half. The auditory and visual stimuli were presented separately between blocks in Experiment 1, while mixed within every block in Experiments 2 and 3. Additional explicit instruction about the short and long modalities was given at the beginning of each block in Experiment 3. The results revealed significant central tendency effects across all experiments. However, the tendency effect was separately centered on the short and long interval group only in Experiment 1, but not in Experiments 2 and 3. We failed to observe any evidence of multiple modality-specific priors in Experiments 2 and 3, suggesting the prior information was developed for the overall range of interval within each block, even when explicit knowledge of the short and long modalities was available.

T4.2 HEARING FLASHES AND SEEING BEEPS: TIMING AUDIOVISUAL EVENTS

Manuel Vidal

Institut de Neurosciences de la Timone, Aix-Marseille Université/CNRS, Marseille, France

Daily life events are often audiovisual (AV), we experience people clapping hands with both our visual and auditory sensory systems. However unimodal signals are transmitted and processed at different speeds, reaching the brain areas responsible for integration at different moments. Signals must somehow be realigned in time to perceive correctly synchronicity. This project aims at characterizing the mutual temporal attraction between senses and determining when exactly is the subjective bimodal event perceived. In every trial participants saw four bimodal AV events regularly spaced in time defining three constant intervals (reference), followed by a fifth unimodal event (test modality). The task was to compare the last interval duration with the reference intervals while attending only the test modality. The reference AV offset was manipulated across trials. Flashes are perceptually shifted in time toward beeps, the attraction being stronger for lagging than leading beeps. Conversely, beeps are never shifted by flashes, indicating a nearly total auditory capture. Subjective timing of the visual component in AV fusion can easily be moved to the future but not the past, an intuitive constrain stemming from minimum visual processing delays. Finally, matching auditory and visual time-sensitivity embedding the beeps in pink noise produces in a very similar mutual attraction of beeps and flashes. In conclusion, when breaking the natural modality appropriateness vision can take over as well, showing that the auditory preference for timing is not hardwired.

T4.3 FROM INTENSITY TO AUDIOVISUAL SIGNAL-INTENSITY VARIABILITY IN TEMPORAL-ORDER JUDGMENTS, AND WHAT ITS EFFECTS REVEAL ABOUT PERCEPTUAL DECISIONS

Lars T Boenke[1,2], Richard Höchenberger[3], Felix Ball[6], David Alais[2], Cees van Leeuwen[4, 5], & Frank W Ohl[1, 6]

[1]Leibniz Institute for Neurobiology, Magdeburg, Germany; [2]The University of Sydney, Sydney, Australia; [3]German Institute of Human Nutrition Potsdam-Rehbrücke, Germany; [4]KU Leuven, Leuven, Belgium; [5]TU Kaiserslautern, Kaiserslautern, Germany; [6]Otto-von-Guericke University, Magdeburg, Germany

Audiovisual simultaneity perception shows high, yet unexplained, variance between studies and individuals. The intensity-effect (i.e. the inverse relationship of signal-intensity and perceptual latency) is considered an exception. However, differences in its magnitude between modalities, tasks, and experimental designs have hitherto remained unaddressed. To investigate these context sensitivities of the intensity-effect, we studied temporal-order judgments (TOJs) of auditory and visual stimuli in three within-participant experiments. We considered how presentation-statistics of intensity-values within the auditory and visual modality affect simultaneity

perception. In one experiment two intensity-values varied at equal rates in both modalities, the other experiments had reduced variability in either the visual or auditory modality. We replicated in both modalities an intensity-effect. Reducing intensity variability within one modality also reduced the intensity-effect for that modality, but more for the auditory than for the visual modality. Moreover, we observed an increasing bias towards the varied modality (i.e. giving on average more first responses to the modality of which intensity was varied). Differences in variability across modalities systematically influenced inter-individual variance in responses: while reducing intensity variability in the auditory modality yielded a decrease in inter-individual variance, reducing variability in the visual modality yielded an increase. This effect was understood as a proclivity in individuals to follow their default-bias in case of sensory uncertainty. That is, participants who have a default-bias towards the auditory modality increase this tendency under uncertainty; and vice versa in participants with visual default-bias. We conclude that inter-individual variance is more than a nuisance variable and discuss theoretical implications.

T4.4 CROSS-MODAL DISTORTION OF TIME DURING PREPARATORY MOVEMENTS

Maria Concetta Morrone[1], Alice Tomassini[2,3], Tiziana Vercillo[3], Giulio Sandini[3]

[1] Department of Translational Research on New Technologies in Medicine and Surgery, University of Pisa, Italy; [2] Donders Institute for Brain, Cognition, and Behaviour, Centre for Cognition, Radboud University Nijmegen, The Netherlands; [3] Department of Robotics, Brain and Cognitive Sciences, Istituto Italiano di Tecnologia, Italy

Time mechanisms are closely linked to the coordinate frames of reference of the motor, visual and haptic systems. Visual time becomes severely compressed at the time of saccades, and can even appear to run backwards (Morrone et al, Nature Neuroscience 2005; Binda et al Journal of Neuroscience 2009). Similar effects occur during the preparation of hand movements for tactile stimuli (Tomassini et al, Journal of Neuroscience 2014). In both cases, the time compression begins approximately 200 ms before movement onset, and increases up to 15% until just before the hand or eye starts to move and continues during the movement. Here we examine whether the time compression is cross-modal, measuring visual time perception during hand or finger movement. The results show that time perception during preparation of isometric contractions and real movements of the hand have similar dynamic and comparable modulations, excluding explanations based on movement-induced sensory masking or attenuation. Most importantly, and surprisingly, changes in visual time depend on the direction of movement: expansion occurs for force away from the body, compression for force towards the body. The cross-modal effect also occurs during rhythmic finger tapping, with the maximum time expansion (about 15%) at half of the tapping interval. These results show that the motor signals have a leading role in the multimodal brain time-keeping mechanism. We suggest that the effects result from the synchronized activity of visual areas and the motor area as part of the mechanism subserving sensory-motor integration (Tomassini et al, JN 2015).

T4.5 AUDIOVISUAL ILLUSORY AND INVISIBLE "RABBITS": THE ROLE OF POSTDICTION IN CROSSMODAL SPATIOTEMPORAL DYNAMICS

Shinsuke Shimojo

California Institute of Technology, USA

Postdiction is the temporal paradox of stimuli following an event affecting that event's perception. This study examines whether audition can alter the location of a visual flash or suppress a visual flash postdictively (Author, 2001). A sequence of flashes (13 ms each, total stimulus duration 145ms) was presented at a 10-degree eccentricity (below fixation) with apparent left-to-right horizontal motion, while beeps (7 ms each) were presented on a single left-hand-side speaker. Stimuli such as: 2 Flashes 3 Beeps [2F3B] and 3 Flashes 2 Beeps [3F2B] were studied. Participants (N = 8) perceived significantly more flashes with 2F3B than 2F2B ($p < 10$-

33) (Illusory Rabbit). The second flash (of three reported flashes) location for 2F3B was midway between the first and third flash, indicating postdictive determination of its location. Even when the direction of apparent motion was unpredictable, the second flash location was still shifted toward the third flash, thereby postdictively determined ($p<10^{-6}$). The stimulus 3F0B was perceived as three flashes, whereas 3F2B was perceived as two flashes (Invisible Rabbit). The number of perceived flashes was significantly greater when the beep-flash pairs preceded the lone flash [3F2B-r], rather than when flanking it [3F2B] ($p = 10^{-8}$) indicating postdictive suppression in 3F2B. Thus, the second flash in the Illusory Rabbit is created and localized postdictively. Likewise, the second physical flash in the Invisible Rabbit is suppressed postdictively. Auditory-visual perception, just as unimodal perception, undergoes postdictive processing.

TALK SESSION 5: MECHANISMS FOR MULTISENSORY INTEGRATION: FROM SINGLE NEURON TO BEHAVIOR

Friday June 17th 10:10-11:25

Chair: Mark Wallace

T5.1 NEURAL CORRELATES OF AUDITORY-TACTILE INTEGRATION

Juan Huang[1], Tianxu Wu[2], Xiaoqin Wang[3]

[1] Johns Hopkins University; [2]Tsinghua-Johns Hopkins Joint Center for Biomedical Engineering Research and Department of Biomedical Engineering, Tsinghua University, Beijing, P.R. China; [3] Department of Biomedical Engineering, The Johns Hopkins University, Baltimore, Maryland

Previous studies have shown that concurrently presented auditory and tactile stimulation can be perceptually integrated by human subjects. A recent study from our lab has provided evidence of auditory and tactile integration in music meter perception. How the brain accomplishes this integration remains mostly unknown. In this study, we examined the neural correlates of auditory and tactile integration in music meter perception. Electroencephalogram signals (EEG) were recorded from 15 human subjects while they were presented with uni-modal auditory, uni-modal tactile, or auditory-tactile bi-modal music note sequences. Event related potentials (ERPs) and steady-state evoked responses (SSERs) were analyzed according to different note types and trial conditions. Results showed that the ERP components corresponding to bi-modal conditions have significantly stronger power and shorter latency comparing with uni-modal conditions, indicating that the brain can integrate music meter information when it's presented separately in auditory and tactile modalities. In addition, when a stimulus sequence contained meter structure, the SSERs reflecting the rhythm frequency was significantly enhanced in bi-modal conditions than in uni-modal conditions. Such bi-modal enhancement in SSERs was not observed in random sequences with the same rhythm frequency but without meter structure. Meanwhile, the phase coherence of SSERs was greater in bimodal auditory condition than in uni-modal auditory condition. In summary, this study shows that the auditory-tactile integration significantly enhances the neural processing of temporal sequences with a pattern or structure. These findings help further understand how the brain processes temporal patterns of sensory inputs and performs multi-modal integration.

T5.2 PREFERENCE FOR VISUAL MOUTH MOVEMENTS PREDICTS AUDITORY RESPONSE IN HUMAN SUPERIOR TEMPORAL SULCUS

Lin L. Zhu, Michael S. Beauchamp

Baylor College of Medicine, USA

Speech perception is a multisensory process that uses both visual information from the talker's face and auditory information from

the talker's voice. The superior temporal sulcus (STS) is a key brain locus for multisensory integration but little is known about its neuroanatomical organization. Previous studies have shown that subregions of the STS respond to visually-presented mouth movements, visually-presented eye movements, and auditory stimuli. We hypothesize the existence of a relationship between these different axes of selectivity. Because visual mouth movements are a necessary prerequisite for vocal production, we hypothesized that regions of the STS with a preference for visual mouth movements should respond strongly to auditory stimuli. To test this hypothesis, we used blood oxygenation level dependent (BOLD) functional magnetic resonance imaging (fMRI) to scan twenty subjects. In each subject, we identified STS voxels that showed a preference for visual mouth movements. These voxels showed a greater response to auditory speech than eye-movement preferring voxels (1.4±0.2% vs. 0±0.1%, $p=3.8x10-10$) with a positive correlation between mouth-preference and auditory response ($m=0.22$, $r2=0.77$, $p=0.009$). Next, we examined whether the auditory response was selective for vocal stimuli. Mouth-preferring voxels responded more to vocal than non-vocal stimuli (1.2±0.1% vs. 0.5±0.1%, $p=5.9x10-6$) with a correlation between mouth-preference and vocal-preference ($m=0.18$, $r2=0.96$, $p=1.3x10-4$). Our study demonstrates that subregions of the STS respond strongly to both visually-presented mouth movements and auditory speech, suggesting that these stimulus features are coded together in small populations of STS neurons.

T5.3 NEURAL CORRELATES OF PERCEPTUAL WEIGHTS DURING AUDIO-VISUAL INTEGRATION

Stephanie C. Boyle, Stephanie Kayser & Christoph Kayser

Centre for Cognitive Neuroimaging, Institute of Neuroscience and Psychology, University of Glasgow.
Glasgow, United Kingdom.

We investigate the neural mechanisms underlying audio-visual cue integration by combining a rate discrimination task with EEG, cue integration models and multivariate classification methods. Subjects' judged the stimulation rate of auditory, visual, and audio-visual stimuli that varied in rate (8 to 15 Hz, 900ms duration), congruency, and reliability of the visual stimulus while brain activity was recorded using EEG. To calculate behavioural weights for each modality, we regressed behavioural choice against cumulative auditory and visual stimulation rate. This revealed strong weights that changed with reliability early in the trial (<400ms), and that correlated ($r=0.61$, $p<0.05$) with perceptual weights derived from subjects' psychometric curves. To determine neural weights associated with auditory and visual stimuli, we used single-trial linear discriminant analysis to extract the neural component that best discriminated between stimulation rates. We found strongest discrimination accuracy (61%) early in the trial (225ms) and scalp activity components over fronto-central electrodes. We then regressed single-trial activity of this decoding component against the auditory and visual rates at each time point. Neural weights were also strongest early in the trial (100-300ms), and there was higher auditory weighting when the visual reliability was low. Finally we tested for a relationship between behavioural and neural weights by correlating the two at each time point. This revealed significant (at $p<0.05$) results during three time windows (430:470ms, 570:590ms and 720:815ms). These results show that we can uncover significant neural correlates of behavioural weights early during audio-audiovisual integration, and that both behavioural and neural weights change with sensory reliability.

T5.4 PREDICTING THE MULTISENSORY RESPONSE OF INDIVIDUAL NEURONS

Benjamin A. Rowland, Ryan L. Miller, & Barry E. Stein

Wake Forest School of Medicine, USA

Neurons in the superior collculus (SC) integrate concordant visual and auditory signals to generate enhanced multisensory responses, boosting the physiological salience of the generating event and facilitating its detection and localization. How they accomplish this has been the subject of numerous speculations. A robust statistical analysis of neural responses to visual and auditory cues presented

alone and in combination reveals two fundamental principles: unisensory signals appear to be integrated continuously and in real-time as soon as they arrive at target neurons, and the multisensory computation is influenced by a delayed, calibrating inhibition. These principles were tested for sufficiency in describing the multisensory transform at the single neuron level by embedding them in an artificial neural network model and determining whether this model could predict the exact moment-by-moment response to a cross-modal cue combination given only knowledge of a neuron's response to the individual modality-specific component cues. The model's predictions were shown to be highly accurate, reliable, and unbiased, and were in many cases not statistically distinguishable from the neuron's actual multisensory responses. This new development allows us to predict more general properties of the response, such as the relationship between the products of multisensory integration and the temporal asynchrony between the cues. It also demonstrates how current perspectives underestimate the commonality of superadditive multisensory products. Supported by NIH grants EY016716 and EY022458 and the Tab Williams Foundation.

T5.5 A NEW MEASURE OF MULTISENSORY INTEGRATION

Hans Colonius[1], Adele Diederich[2]

[1] Oldenburg University, Germany; [2]Jacobs University Bremen, Germany

A single neuron is categorized as multisensory if there is a statistically significant difference between the mean responses evoked by a cross-modal stimulus combination and that evoked by the most effective of its components individually. The most widely used quantitative index expresses multisensory enhancement (or inhibition) as a proportion of the strongest unisensory response. Despite its descriptive value, this index is mute with respect to the possible operations a neuron may perform in combining unisensory inputs to yield the multisensory response. In particular, being responsive to multiple sensory modalities does not guarantee that a neuron has actually engaged in integrating its multiple sensory inputs rather than simply responding to the most salient stimulus. In complete analogy to the race model inequality test routinely applied to testing reaction time facilitation in behavioral studies, here we suggest an alternative measure for single neuron data based on probability summation. The new index compares the mean observed cross-modal response of a neuron with the largest cross-modal mean achievable by stochastically coupling its unisensory responses. Computation of the new index is straightforward and, while being as amenable to statistical testing as the traditional one, it is also sensitive to changes in response variability. Because it is, in general, more restrictive than the traditional one, many neurons previously categorized as multisensory may possibly lose that property. The approach is illustrated by 84 recordings from 20 cells (Wallace lab). We will report bootstrapped confidence intervals for the difference between the new and the traditional measure with and without removing spontaneous activity.

TALK SESSION 6: MULTISENSORY SPEECH PERCEPTION AND ENHANCEMENT

Friday June 17th 14:35-15:50

Chair: Salvador Soto-Faraco

T6.1 INTERACTIONS BETWEEN PHYSICAL AND SEMANTIC TEMPERATURE

Yizhen Zhou, Hsin-Ni Ho, Junji Watanabe

Department of Information Processing, Tokyo Institute of Technology, Japan

Classical theories assume that meaning arises from the combination of symbols which have little connection with the external physical world. However, recent studies challenged it with the alternative theories, the “embodied” or “grounded” models, which suggest that semantic processing is grounded in representations of actual objects and physical environments. A well-known set of findings from

the grounded cognition is focused on the interaction between sentence processing and visual/auditory perception. Although there are previous researches revealing the semantic interference and facilitation in haptic perception such as weight, the empirical demonstration of grounding semantics of language in haptics is still insufficient especially in thermal sensation. In order to determine the strength of semantic association between thermal sensations and their lingual descriptions, we performed experiments of speeded target categorisation for the thermal quality, “hot” and “cold”, while presenting physical thermal stimulation to the participant. The target stimuli were shown in the form of semantic words, illustrative figures, and auditory recordings. The results suggested that the experience of physical temperature facilitated the internal processing of meaning, the response latencies of congruent conditions were faster than incongruent ones.

T6.2 INTER-TRIAL VARIABILITY OF MCGURK-EFFECT REVEALS MULTI-LEVEL NEURO-MARKERS OF MULTISENSORY SPEECH PERCEPTION

Vinodh Kumar

National Brain Research Centre, India

Observable lip movements of the vocalizer influences perception of auditory speech. A classical example of this influence is reported by listeners who perceive an illusory speech sound (McGurk-effect) when presented with incongruent audio-visual(AV) speech stimuli. Recent neuroimaging studies of AV speech perception accentuate the role of frontal, parietal and the integrative brain sites in the vicinity of the superior temporal sulcus (STS) for speech perception. However, when and at what level of organization do such networks emerge is an open question. We posit that a large scale functional connectivity among the neural population situated in the aforementioned brain sites may provide valuable insight involved in processing and fusing of AV speech. Varying the psychophysical parameters in tandem with electroencephalogram (EEG) recordings, we exploited the trial-by-trial perceptual variability of incongruent audio-visual (AV) speech stimuli to identify the neuro-markers of AV integration that facilitates a specific perceptual experience. We show that a neurocognitive component as early as 120 ms post stimulus onset as a potential marker for multisensory perception. We also demonstrate multisensory perception is likely to be associated with an increased beta (16-30 Hz) and gamma (30-45 Hz) band post stimulus activity. At large-scale network level we show an enhancement in global coherence in beta and gamma bands exclusively during multisensory perception indicating global functional connectivity among candidate brain regions. Together, we report a multi-level representation of task relevant activity in the temporal, spectral and at network level, capturing the complex neuronal mechanisms underlying multisensory speech perception.

T6.3 GENETICALLY MEDIATED DIFFERENCES IN THE MCGURK EFFECT — A MULTISENSORY SPEECH ILLUSION

Guo Feng[1], Wen Zhou[1], Michael S. Beauchamp[2]

[1]Institute of Psychology, Chinese Academy of Science, China; [2]Department of Neurosurgery and Core for Advanced MRI, Baylor College of Medicine, USA

Multisensory integration of auditory and visual speech facilitates human communication. A sensitive assay of this integration is the McGurk effect, an illusion in which incongruent visual speech information dramatically changes the percept of auditory speech. Recent research has revealed substantial variability in the McGurk effect, with some subjects never perceiving the illusion and others always perceiving it. However, the source of this variability is unknown. To examine if genetic factors play a role, we measured the McGurk effect in 73 monozygotic (MZ) twin pairs and 89 dizygotic (DZ) twin pairs, retesting a subset of the pairs two years later. The best-fitting genetic model attributed 29% of the variance in the perception of the illusion between individuals to additive genetic factors. The results point to a previously unknown link between genes and multisensory speech perception, an important brain function at the

boundary of perception and cognition.

T6.4 A CAUSAL INFERENCE MODEL EXPLAINS PERCEPTION OF THE MCGURK EFFECT AND OTHER INCONGRUENT AUDIOVISUAL SPEECH

John F. Magnotti and Michael S. Beauchamp

Baylor College of Medicine, USA

Audiovisual speech integration combines information from auditory speech (talker's voice) and visual speech (talker's mouth movements) to improve perceptual accuracy. However, if the auditory and visual speech emanate from different talkers, integration decreases accuracy. Therefore, a key step in audiovisual speech perception is deciding whether auditory and visual speech have the same source, a process known as causal inference. A well-known illusion, the McGurk Effect, consists of incongruent audiovisual syllables, such as auditory "ba" + visual "ga" (AbaVga), that are integrated to produce a fused percept ("da"). This illusion raises two fundamental questions: first, given the incongruence between the auditory and visual syllables in the McGurk stimulus, why are they integrated; and second, why does the McGurk effect not occur for other, very similar syllables (e.g., AgaVba). We describe a Bayesian model of causal inference in multisensory speech perception (CIMS) that predicts the perception of arbitrary combinations of auditory and visual speech. We applied this model to behavioral data collected from 265 subjects perceiving both McGurk and non-McGurk incongruent speech stimuli. The CIMS model successfully predicted both the audiovisual integration observed for McGurk stimuli and the lack of integration observed for non-McGurk stimuli. An identical model without causal inference failed to accurately predict perception for either form of incongruent speech. The CIMS model provides a computational framework for studying how the brain performs one of its most important tasks, integrating auditory and visual speech cues to allow us to communicate with others.

T6.5 TRACKING ACOUSTIC FEATURES OF SPEECH IN EARLY BLIND INDIVIDUALS USING MEG

Markus J. van Ackeren, Francesca Barbero, Stefania Mattioni, Roberto Bottini, Olivier Collignon

University of Trento, Italy

Previous studies have demonstrated that occipital areas in blind individuals robustly respond to auditory information up to the level of language comprehension. What features of speech does occipital cortex code for exactly? Using magnetoencephalography (MEG) we investigated if, and at what level (e.g., phonemes syllables, or words) occipital and temporal cortices in the blind entrain to rhythmic acoustic features of speech. We tested early blind and sighted individuals while participants listened to segments from audio books with different levels of spectral distortion. Computing coherence between the speech envelope and the MEG signal we find that neuronal populations in auditory cortex follow the speech rhythm at a temporal scale corresponding to the syllabic rate in our speech stimuli. Strikingly, in blind individuals as compared to sighted controls speech tracking was also observed in the occipital cortex, with early visual cortex showing the highest sensitivity to speech. Our results provide a novel way to address how occipital areas in the blind contribute to speech comprehension by demonstrating that occipital cortex of blind individuals is sensitive to speech down to the level of rhythmic acoustic properties, such as the syllabic rate.

TALK SESSION 7: COUPLING OF PERCEPTION AND ACTION CONTROL

Saturday June 18th 10:40-11:55

Chair: David Burr

T7.1 IS THERE MULTISENSORY INTEGRATION FOR THE ONLINE CONTROL OF VOLUNTARY ACTION?

Luc Tremblay, Darrin Wijeyaratnam, John de Grosbois, Stephen Bested, Rachel Goodman, Valentin Crainic

University of Toronto, Canada

Both vision and proprioception are thought to contribute to the control of ongoing limb trajectories via multiple processes (e.g., Bagesteiro et al., 2006; Elliott et al., 2010; Tremblay et al., 2013). According to Elliott et al. (2010), online control mechanisms require the use of both vision and proprioception, which should result in increased importance of vision and proprioception at some point during a movement. In contrast, it has also been argued that vision and proprioception contribute to different aspects of the trajectory (e.g., Bagesteiro et al., 2006: vision primarily contributes to controlling movement distance whereas proprioception can be used later in the trajectory, to implement online corrections). However, no known investigations of online control mechanisms have directly manipulated the reliability of proprioceptive feedback in neurologically intact individuals. To directly test for the importance of vision and proprioception for the online control of reaching movements, the current study implemented: 1) a dual-muscle between-trial tendon vibration manipulation on one of two blocks of trials, and 2) vision occlusion during the movement on 50% of the trials. The proprioceptive perturbation only yielded significant endpoint biases. In contrast, vision occlusion also yielded increased endpoint variability and more evidence of online trajectory amendments. While proprioception was important to determine the ultimate movement endpoint, only vision appeared to significantly contribute to the online control of reaching movements. As a result, it is worth further investigating if multisensory integration takes place for the online control mechanisms of voluntary movements.

T7.2 SACCADIC PREPARATION TRIGGERS VISUAL OSCILLATIONS IN CONTRAST SENSITIVITY

Alessandro Benedetto[1,2] and M. Concetta Morrone[2,3,4]

[1]Department of Neuroscience, Psychology, Pharmacology and Child Health, University of Florence, Florence, Italy; [2] Department of Translational Research on New Technologies in Medicines and Surgery, University of Pisa, Pisa, Italy; [3] Neuroscience Institute, National Research Council, Pisa, Italy; [4] Scientific Institute Stella Maris, Pisa, Italy

Action can profoundly influence perception; one clear case is saccadic suppression, the reduced visibility around the time of saccades [1], another is the oscillatory modulation of visibility synchronized with hand action [2-3]. Here to reveal visual oscillations, we investigated psychophysically the effect of saccades on contrast discrimination sensitivities, measuring the temporal dynamics of visual contrast increment threshold before, during, and after rhythmic saccade execution. Subjects (N=6) made 20° horizontal saccades at will to stationary saccadic target. At a random interval, a brief (10ms) Gabor patch was displayed between the fixations. Subjects were required to detect by 2AFC a contrast increment in either the upper or lower field. We observed that contrast sensitivity fluctuates rhythmical at about 3 Hz, commencing 0.5 second before saccade execution and lasting around 1 second. The results show that saccadic preparation triggers visual oscillations in the delta range. Interestingly, the classical peri-saccadic suppression was systematically embedded in the troughs of these oscillations. We suggest that the corollary discharge signal plays a key role in synchronizing action and perception over long time, helping to optimize visual exploration and to maintain visual stability.

T7.3 CAUSAL INFERENCE IN MULTISENSORY HEADING ESTIMATION

Ksander N. de Winkel, Heinrich H. Bülthoff

Max Planck Institute for Biological Cybernetics, Germany

A large body of research shows that the Central Nervous System (CNS) integrates multisensory information in a fashion consistent with Bayesian Inference. However, this strategy should only apply when multisensory signals have a common cause; when signals have independent causes, they should be segregated. We recently developed a Causal Inference (CI) model that can account for this notion in multisensory heading estimation (De Winkel, Katliar, and Bülthoff, 2015). In this particular study, participants were presented with visual-inertial horizontal motion stimuli with various headings and a wide range of discrepancies. Surprisingly, the data suggested that multisensory signals were always integrated–regardless of the discrepancy. In the present work, we hypothesized that the CNS accumulates evidence on signal causality over time. In other words, signals will be segregated when a common cause is unlikely, and integrated otherwise. To test this hypothesis, we expanded the experimental paradigm of the previous study by increasing both the incidence of stimuli with large discrepancies and the range of motion durations. The results reflect CI for the majority of our participants. For some participants, discrepant stimuli were more likely to be integrated for short, and segregated for longer motion durations. We conclude that the CNS includes judgments of signal causality in the heading estimation process. This result may have been occluded in previous research by a relatively low incidence of stimuli with large discrepancies. Moreover, we present evidence that CI is likely to result from an accumulation of evidence over time on signal causality.

T7.4 WALKING TO A MULTISENSORY BEAT: BENEFITS OF AUDIO-TACTILE RHYTHMIC STIMULATION

Charlotte Roy

University of Montpellier, France

Living in a complex and multisensory environment involves constant interaction between perception and action. Sensorimotor integration engaged by multimodal stimulation can be studied via a cued walking task. Even if there is evidence of multisensory benefit in sensorimotor tasks (Elliott, Wing, & Welchman, 2010; Wright & Elliott, 2014), during walking the results are mitigated (Sejdić, Fu, Pak, Fairley, & Chau, 2012). Benefits of multimodal stimulation can be linked to a temporal window of integration (TWI). The existence of a TWI, observed in both perception and sensorimotor tasks (Diederich & Colonius, 2015), suggests that the response to asynchronous cross-modal stimuli is invariant for a certain range of time differences between modalities. In this study we examined whether the TWI generalizes to gait. To this aim, we tested the effect of audio-tactile rhythmic cueing on the stability of gait and on synchronization to the cues in healthy young adults. Participants walked with audio-tactile rhythmic cues, with various stimulus onset asynchronies (from -160 to 160 ms). There is evidence of a TWI (i.e., up to 80 ms) on gait stability and on the variability of the synchronization to the cues. Moreover, a multisensory benefit was found but conditioned by the time course of the trial, revealing an effect of adaptation. This benefit is weak or absent at the beginning and in the middle of the trial and clearly increases at the end. These findings extend the temporal rule of multisensory integration to continuous movement and increase our knowledge on temporal adaptation.

T7.5 A SHARED NUMERICAL REPRESENTATION FOR ACTION AND PERCEPTION

David Burr, Irene Togoli, Giovanni Anobile & Roberto Arrighi

Department of Neuroscience, Florence University, Italy

Much evidence has accumulated to suggest that in many animals, including young human infants, there exists a neural mechanism dedicated to estimating approximate quantity: a *sense of number*. Most research has concentrated on spatial arrays of objects, but there is also good evidence that temporal sequences of number are encoded by similar mechanisms (Arrighi et al, Proc. Roy. Soc., 2014). Processing of numerical information is fundamental also for the motor system to program sequences of self-movement. Here we use an adaptation technique to show a clear interaction between the number of self-produced actions and the perceived

numerosity of subsequent visual stimuli, both spatial arrays and temporal sequences. A short period of rapid finger-tapping (without sensory feedback) caused subjects to under-estimate the number of visual stimuli presented around the tapping region; and a period of slow tapping caused over-estimation. The distortions occurred both for stimuli presented sequentially, and for simultaneous clouds of dots, when measured by two separate techniques. Our results sit well with neurophysiological studies showing links between number perception and action. We extend these findings by demonstrating that vision and action share mechanisms that encode numbers, and that the 'number sense' serves to estimate both self-generated and external events.

TALK SESSION 8: ATTENTION, VALUE AND REWARD IN MULTISENSORY WORLD

Saturday June 18th 13:05-14:20

Chair: Jared Medina

T8.1 REWARD INTERACTS WITH MODALITY SHIFT IN REDUCING CROSS-MODAL CONFLICT

Guanlan Kang[1], Lihui Wang[1], Xiaolin Zhou[1, 2, 3, 4]

[1]Center for Brain and Cognitive Sciences and Department of Psychology, Peking University, Beijing, China; [2] Key Laboratory of Machine Perception (Ministry of Education), Peking University, Beijing, China; [3] Beijing Key Laboratory of Behavior and Mental Health, Peking University, Beijing, China; [4] PKU-IDG/McGovern Institute for Brain Research, Peking University, Beijing, China

Previous studies have shown that reward can enhance cognitive control and reduce conflict in visual processing. Here we investigate: 1) whether/how reward influences cross-modal conflict control, and 2) how the shift of attention across modalities modulates the effect of reward on cross-modal conflict control. In four experiments, a cue indicating reward availability of a given trial (reward vs. no-reward) was presented prior to a target. In reward trials, participants received a certain amount of monetary reward if the response times were faster than the baseline measured previously. The target could be either a visual or an auditory letter, which was accompanied by a distracting stimulus from the other modality. The identity of the distractor was either the same as or different from the identity of the target (congruent vs. incongruent). When the cue modality was constant (Experiments 1 and 2), or changed across different experimental blocks (Experiment 3), the interference effect (i.e., RTs in incongruent trials minus RTs in congruent trials) was smaller following a reward cue than following a no-reward cue, suggesting that reward could reduce cross-modal conflict. By contrast, when the modality of the cue was unpredictably changed trial-by-trial (Experiment 4), reward reduced cross-modal conflict only when the cue modality was different from the target modality. This pattern was replicated in Experiment 5 in which the SOA between the cue and the target was manipulated. These results suggested a flexible reward-driven modulation on cross-modal conflict control.

T8.2 EEG ACTIVITY OF PERCEPTION AND IMAGERY OF VIBROTACTILE STIMULATION

Shusheng Zhang, Yuru Zhang, Xiaojun Xu, Lulu Xu, Dangxiao Wang*

Beihang University, China

When vibrotactile stimulation with constant frequency was exerted on human's skin, brainwave synchronization could be observed, i.e. the Electroencephalography (EEG) signal with same frequency increased. It is unknown whether similar effects exist when human is imaging or recalling a previously experienced vibrotactile stimulus with a particular frequency. In this paper, we measured the EEG activity under perception and imagery of vibrotactile stimuli. Participants received vibrotactile stimulation through their right index finger and then performed tactile imagery tasks by making tactile judgments to discriminate the previously perceived reference stimulus and another test stimulus. The EEG spectrum energy under physical and imaginary stimulation of three different reference stimuli was compared. The results showed that the effect of brainwave synchronization existed during both perception and imagery

of stimulation for two of the reference stimuli (i.e. 7Hz and 15Hz sinusoidal vibration), while no significant changes could be observed for the 10Hz reference stimulus. Furthermore, compared to the baseline EEG signal, the energy within the Theta band (i.e. 4-7 Hz) increased during both the perception and imagery stimulation process of all the three reference stimuli. The results implied the possibility of using imagery of vibrotactile stimulation for brain-computer interfaces and neurofeedback training applications.

T8.3 TANGLED CODES OF FACIAL AFFECTS AND ODOR HEDONICS BELOW AWARENESS

Wei Chen, Kepu Chen, Wen Zhou

Institute of Psychology, Key Laboratory of Behavioral Science, CAS Center for Excellence in Brain Science and Intelligence Technology, Chinese Academy of Sciences

Our reaction to a sensory stimulus depends in large on its attractiveness or aversiveness, viz. valence. It is generally accepted that valence is a continuous variable abstracted from environmental inputs, yet how valence is ascribed to stimuli from various sensory channels has been scantly studied. Combining continuous odor exposure with a well-established paradigm termed interocular suppression, we show that the suppression time of an emotional face is modulated by the hedonic value of its accompanying odor, as if it assumes valence from the olfactory channel in the absence of visual awareness. In parallel, hemodynamic activities in the amygdala exhibit an interaction between facial affect and odor hedonic tone regardless of whether the face is visible or interocularly suppressed from being seen, whereas the fusiform face area responds only to visible facial affect. On the other hand, we find that initially indiscriminable neutral enantiomers gain different hedonic values through implicit pairings with fearful and happy faces, respectively. These results, while underscoring the phylogenetic intimacy between olfaction and emotion, convergently argue against strictly sensory-specific representation of valence. Valence value can in fact be misattributed to stimuli from distinct sensory channels in the absence of awareness.

T8.4 CONTEXTUAL CUEING ACROSS VISION AND TOUCH

Leonardo Assumpção[1], Zhuanghua Shi[1], Xuelian Zang[1,2], Hermann J. Müller[1,3], & Thomas Geyer[1]

[1]Department Psychologie, Ludwig-Maximilians-Universität München, Germany; [2] Research Centre for Special Economic Zone Research, Shenzhen University, China; [3] School of Psychology, Birkbeck College, University of London, UK

A marker of spatial learning is given by faster reaction time performance when the visual target is consistently encountered within a stable spatial arrangement of distractor objects (relative to non-repeated arrangements; i.e., contextual cueing effect; [1]). More recently we were able to show a contextual cueing effect also in tactile search [2]. Given the existence of context effects in both vision and touch, here we asked whether contextual cues are represented in a shared or modality-specific representation. The search task that was divided in a learning and test phase, such as that spatial learning in a visual search task was followed by test on a tactile search task (counterbalanced design). The same arrangements were used in the learning and test phases, which was unbeknown to participants). Participants detected the target faster in repeated relative to novel (baseline) configurations during the learning phase, indicating a clear contextual cueing effect. Importantly, the magnitude of cueing was comparable between the two modalities. During the test phase, contextual cueing was greater for the tactile task, that is, only contextual cues obtained in the earlier visual task were successfully transferred to the later tactile task, but not the other way around. These findings may indicate that the representation underlying contextual cueing could be amodal in nature, but that the transfer of learning depends on the importance (‘dominance’) of the learning modality for spatial cognition.

T8.5 INDIVIDUAL DIFFERENCES IN SYMPTOM SEVERITY IN AUTISM SPECTRUM DISORDER ASSOCIATED WITH MAGNITUDE AND VARIABILITY IN MULTISENSORY PROCESSING

Sarah Baum[1], Matthew De Niear[1,2], Tiffany Woynaroski[3], Stephen Camarata[3], Mark Wallace[1,3]

[1]Vanderbilt Brain Institute, Vanderbilt University; [2]Medical Scientist Training Program, Vanderbilt University Medical School ; [3]Department of Hearing and Speech Sciences, Vanderbilt University

Autism Spectrum Disorder (ASD) is traditionally characterized as a set of deficits in the core domains of social communication and interaction as well as restricted interests and repetitive behaviors. In addition to deficits in these core domains, reports of differences in sensory processing have been known since the first clinical descriptions of autism (Kanner, 1943). Although current work has made great progress to carefully define and characterize sensory processing in ASD in a controlled laboratory setting, very few studies have related research findings back to clinical domains. For example, beyond group level differences, individual differences in multisensory processing have not been mapped to specific aspects of ASD symptomology nor symptom severity. If individual differences in performance map onto clinical symptoms, there is great utility in further examining the role of these sensory differences as potential mechanisms for certain aspects of ASD symptomology. We measured multisensory function in individuals with ASD and individuals with typical development (TD) with 2 laboratory tasks (speeded reaction time [RT] task and the McGurk paradigm). In addition to these laboratory tasks we completed a comprehensive characterization of ASD symptomology using a number of different measures indexing a wide range of functional capacities affected in ASD, including receptive and expressive language and social interaction. First, we examined group differences children with ASD differ from TD on tasks indexing both low-level (simple flashes and beeps) and high-level (speech) multisensory integration. Replicating previous work, we found that individuals with TD show better performance across both multisensory tasks. Second, we sought to examine if low/high level indices of multisensory integration co-vary with concurrent indices of ASD symptomology. We found that both the magnitude (as measured by susceptibility to the McGurk illusion and an decreased RT for multisensory targets) and variability (as measured by a decrease in the intra-individual variability of RT for multisensory targets) in multisensory tasks was related to multiple aspects of ASD symptomology, such that less multisensory integration was associated with worse performance in sensory, communication, and language domains. Finally, we sought to examine if these relationships co-vary according to group. Indeed, these relationships are moderated by group, with a stronger relationship between performance across these core domains and multisensory processing found in individuals with ASD. Given that these relationships between individual differences in multisensory processing and ASD symptomology do exist, indexing multisensory function may provide a valuable tool for predicting later symptomology.

POSTER SESSION

Thursday June 16th 13:30-14:50

P1. EFFECT OF ENDOGENOUS TEMPORAL ATTENTION ON AUDIOVISUAL STIMULI PROCESSING

Yulin Gao

Psychology Department, Jilin University, China

Previous studies have used the cue-target paradigm to study the effect of the endogenous temporal attention on only visual or auditory stimuli. Furthermore, some studies found that the visual and auditory stimuli is not processed in isolation but produce coherent cognition in the brain when the visual and auditory stimuli are simultaneously presented. However, the effect of endogenous temporal attention on audiovisual (AV) stimuli processing is unclear. Utilizing the high temporal resolution of event-related potentials (ERPs), we used a central cue that can predict the time point (600 ms or 1800 ms) of audiovisual target to investigate whether endogenous temporal attention could modulate AV stimuli processing. The results showed that the endogenous temporal attention could not change the amplitude of the early ERP component in conditions of either short (600 ms) or long (1800 ms) cue-target intervals, indicating that the endogenous temporal attention had no effect on the early-stage of AV stimuli processing. However, the late ERP component showed differences between the short (600 ms) and long (1800 ms) cue-target intervals, supporting a model in which endogenous temporal attention might determine the late stage of AV stimuli processing.

P2. EFFECT OF VERTICAL VECTION ON VERTICAL SOUND LOCALIZATION

Zhenglie CUI, Shuichi SAKAMOTO and Yôiti SUZUKI

Research Institute of Electrical Communication, Tohoku University, Japan

During self-motion, the spatial relation between objects and the observer changes temporally. Under such circumstances, self-motion information might be a useful cue to localize sound source positions accurately. This study investigated effects of perceived vertical self-motion induced by vection on sound localization in the median plane. As stimuli, not only vection with constant speed but also that inducing accelerated self-motion perception were presented to observers. Random dots moving vertically on a wide screen were presented to induce vertical self-motion. Auditory stimuli were presented from one of five loudspeakers set behind the screen when an observer perceived the vertical vection. Observers were requested to point to the sound-image position on the screen. Results showed that the perceived sound-image position was shifted when a vertically moving visual stimulus was presented, irrespective of the vection perception. However, no significant effect was found on the vertical shifts of sound localization by the perception of vection with constant speed or that with acceleration. These results suggest that vertical motion in the visual stimulus is codified as object movement and not as self-motion, resulting in the absence of vertical shifts of sound localization by vection.

P3. DEVELOPMENT OF EMBODIED SENSE OF SELF SCALE (ESSS)

Tomohisa Asai[1], Noriaki Kanayama[2], Shu Imaizumi[3], Shinichi Koyama[3], Seiji Kaganoi[4]

[1] NTT Communication Science Laboratories, Japan; [2] Hiroshima University, Japan; [3] Chiba University, Japan; [4] Geisei Hospital,

Japan

The scientific exploration of the self has progressed, with much attention focused on the embodied sense of self (ESS). Empirical studies have suggested the mechanisms for self-representation. On the other hand, less attention has been paid to the subjectivity itself of the self. With reference to previous studies, the current study collected items that reflect the ESS and statistically extracted three factors for it: Ownership, Agency, and Narrative. The developed questionnaire (Embodied Sense of Self Scale, ESSS) showed good enough validity and reliability for practical use. Furthermore, ESSS discriminated schizophrenia, a disorder of the ESS, from controls. We discuss the factorial structure of ESS and the relationship among factors on the basis of the current results.

P4. MOTOR-AUDITORY TEMPORAL RECALIBRATION IS MORE ROBUST THAN MOTOR-VISUAL ONE TO MODIFY PERCEPTUAL LATENCY

Yoshimori Sugano [1], Mirjam Keetels [2], and Jean Vroomen [2]

[1]Department of Industrial Management, Kyushu Sangyo University, Japan; [2]Department of Cognitive Neuropsychology, Tilburg University, the Netherlands

Perception of synchrony between one's own action and its sensory feedback can be recalibrated after exposure to an induced delay between them (temporal recalibration: TR). Theoretically, motor-sensory TR results from a compensatory shift of timing in either a motor and/or a sensory component. To date, however, it is uncertain which component plays a dominant role. In this study, we directly addressed whether perceptual latency changes after the motor-sensory TR. We used both a simple reaction time (RT) task and a synchronous tapping task (ST) for measuring a change of perceptual latency and the motor-sensory TR respectively. The motor-sensory TR manifested itself as a larger anticipation error in the ST task after exposure to delayed feedback. If it accompanies with a change of perceptual latency, a reaction time in the RT task should be reduced to compensate the delay. Participants were exposed to a delayed (150 ms) visual or auditory feedback (e.g., flash or click) after voluntary action (e.g., finger tapping), and then immediately did both RT and ST tasks in this order. An exposure to a subjectively synchronous (50 ms) feedback served as a control. The results showed that there was a reliable auditory TR (~21 ms) that accompanied with a reduction of auditory latency (~8 ms). In contrast, there was no significant visual TR and no significant change of visual latency. These results suggest that the auditory TR is more potent and robust than the visual TR that can modify auditory latency.

P5. MULTISENSORY INTEGRATION VARIES WITH TARGET AND ENVIRONMENT COMPLEXITY IN A VIRTUAL ENVIRONMENT: TOWARDS A NATURALISTIC MODEL OF MULTISENSORY INTEGRATION

Hudson Diggs Bailey, Aidan Browne Mullaney, Kyla David Gibney[1], Leslie Dowell Kwakye[2]

[1] Vanderbilt University Imaging Institute, USA; [2] Oberlin College, USA

We are continually bombarded by information arriving to each of our senses; however, the brain seems to effortlessly integrate the separate information into a unified percept. Although multisensory integration has been researched extensively using simple computer tasks and stimuli, much less is known about how multisensory integration functions in a real world context. Virtual reality offers the perfect combination of realism and precise control over the environment to investigate this question. We have chosen to begin this area of investigation with a task known as the detection task (redundant target effects). In its computer game version, participants are asked to detect a white circle, white noise burst, or a combination of the two as fast as possible. Participants are faster at detecting multisensory targets than either of the unisensory targets. In the virtual reality version of this task, participants detected targets varying in complexity within a virtual world that also varied in complexity. The environmental complexity was

modulated using the three following virtual worlds: a gray room that contains no depth cues, texture, color, or environmental sounds; a room with textured walls that offers depth cues, soft background white noise, but no color or environmental context; a room that mimics the experimental testing room that offers depth cues, texture, color, and identifiable background noise. The target complexity was modulated using the following three conditions: white circle with no 3D shading and/or white noise burst; white circle with 3D shading thus appearing as a white ball and/or noise which is modulated in amplitude and frequency; tennis ball with 3D shading and color and/or a tennis ball sound. Using the geometric measure of Miller's inequality proposed by Colonius and Diederich (2006), we demonstrated integrative effects in every environment-target pairing and further showed that the degree of integration positively correlates with target complexity but only in our most complex environment. To further investigate this effect of target complexity on integration, we conducted a second experiment to examine the effect of target unpredictability. The effect of target complexity observed in the first experiment did not hold when the target identity or location were unpredictable; however, we were able to observe integrative effects in every condition. Our study is the first to definitively show that minimal and more naturalistic stimuli elicit comparable redundant target effects but that the features of the environment and target modulate the degree of integration.

P6. NEURAL PRACTICE EFFECT DURING CROSS-MODAL SELECTIVE ATTENTION: GENERAL AND MODALITY-SPECIFIC EFFECTS

Jing Xia, You Li, Lu Shen, Ying Fang, Hui Li, Nan Liu, Yizhou Jiang, Qi Chen

South China Normal University, Guangzhou, China

The practice effect on cerebral cortex is a process that practice and experiences gradually modify the central nervous system. Knowing the effect of practice on cortical plasticity is important for us to understand the neural mechanisms of cortical reorganization as well as the mechanisms of function recovery after brain injuries. However, it is still unknown whether practice effect reflect the general mechanisms of selective attention or it changes with the attended sensory modality. In two fMRI studies, we adopted a hybrid design to investigate how neural activity changed with practice. The temporal position of each trial in a given block was included as a covariate in the general linear model of the fMRI data, to calculate the first and second order parametric modulation effects of the temporal order of a single trial in a block. Our results showed a general practice effect mechanism of selective attention that neural activity in the default mode network increased linearly with the practice, on the other hand, neural activity in the PPC and DLPFC decreased linearly with the same practice and the region of SMA showed nonlinear activation, which enhanced only at the onset and offset of a block while was sustained during the block. The psychophysiological-interaction result demonstrated a modality-specific practice effect of selective attention. When attended auditory stimuli, the functional connectivity between STG and both dorsal and ventral visual stream decreased with the practice, however, when participants focused on visual stimuli the functional connectivity reduction only happened between the STG and ventral visual stream.

P7. EFFECT OF GALVANIC VESTIBULAR STIMULATION ON VISUAL TARGET LOCALIZATION

David Hartnagel[1], Jean-Louis Vercher[2], Lionel Pellieux[1] & Patrick MB Sandor[1]

[1] Institut de Recherche Biomédicale des Armées, France; [2] Institut des Sciences du Mouvement, France

Space perception results from the integration of various sensory signals, mainly visual, somatosensory and vestibular (Lackner and DiZio, 2005). The present study focuses on the interaction between visual and vestibular systems. Orientation perception and posture can be influenced by galvanic vestibular stimulations (GVS). This perturbation provokes "virtual rotation vector" in roll (Day and Fitzpatrick, 2005) leftward or rightward, depending of the current flow direction. In healthy subjects the GVS effect has been mostly investigated with subjective vertical judgement (visual or haptic) or horizontal bisection task (Utz et al., 2010). Here we used the GVS

to test the effect of a virtual rotation on visual targets localization. The goal is to investigate visuo-vestibular interactions in a large 2D environment without asking the participant to focus on the gravity direction. Participant sat on a chair with his/her head maintained by lateral headrests. In darkness, participant had to localize a visual target (100 ms duration) by moving a green laser dot with a trackball. This task was performed under 3 random conditions (no GVS and 2 GVS flow directions, 2.5 mA) to simulate a left or right rotation for 5 consecutive trials in the same GVS condition (around 40 s including 1.5 s upward/downward ramps and 5 s starting stabilization). After the localization experiment, participant was asked to judge about the verticality in the 3 GVS conditions by holding a rod vertically. Results show that GVS's flow direction has variable effects depending on visual target locations consistently with the vertical subjective judgements.

P8. EXPERIMENTAL CONTEXT MODULATES MSI BY ALTERING UNISENSORY BASELINE CONDITIONS

Felix Ball[1, 2], Lara E. Michels[1], Johanna Starke[1, 2], Toemme Nösselt[1, 3]

[1]Biological Psychology, Otto-von-Guericke University, Magdeburg, Germany; [2] University Clinic for Neurology, Otto-von-Guericke University, Magdeburg, Germany; [3] Center for Behavioral Brain Sciences, Magdeburg, Germany

There is converging evidence that multisensory interplay (MSI) can enhance perceptual sensitivity and some have argued that this enhancement reflects automatic integration across modalities. In a series of psychophysical experiments we tested if MSI-induced behavioral benefits do indeed remain unchanged under different experimental contexts; hence can be considered to reflect automatic processing. In all experiments auditory (A) and/or visual (V) stimulus sequences were presented either alone or simultaneously. Sequences comprised 11 stimuli (duration/ISI 100ms). Participants discriminated the visual and/or auditory frequency of the deviant target stimulus (high/low) within each sequence. Moreover, temporal expectation about time-of-target-occurrence was manipulated block-wise: targets preferentially occurred either early ('early block') or late ('late block') within the stimulus sequence. Task difficulty was further altered by using speakers ('same location', Exp. 1 & 2) or headphones ('different location', Exp. 3), and by changing the predictability of target modality (predictable: Exp.1 & 3, unpredictable: Exp. 2). Note that in all experiments audiovisual sequences with bimodal targets were employed among others. Despite the similarities in experimental design across experiments, we observed distinct effects for MSI: there was multisensory inhibition in Experiment 1 (max[A,V,] > AV) , multisensory enhancement in Experiment 2 (max[A,V,] < AV), and partial evidence for multisensory enhancement in Experiment 3 (max[A,V,] <= AV). However, a direct comparison of performance for all conditions across experiments revealed that performance was virtually identical for bimodal target conditions, whereas differential performance across experiments were observed for unimodal target conditions. These results challenge traditional notions of automatic MSI.

P9. RECOGNIZING COLLECTIVE HUMAN EMOTIONAL EXPERIENCE DURING VIDEO WATCHING USING EEG-BASED INTER-SUBJECT NEURAL CORRELATIONS

Xin Hu, Dan Zhang

Department of Psychology, Tsinghua University, Beijing, China

Although human emotional experience plays an important role in our daily lives, its quantitative measurement remains to be one of the most challenging problems. The conventional event-related analysis methods may not be the most suitable tools as the real-world emotional stimuli are usually associated with continuous audiovisual streams. In the present study, we explored the neural characteristics of collective human emotional experience using inter-subject neural correlation (ISNC). ISNC measured the reliability of neural responses across a group of participants rather than event-related response strength; it is hereby considered as a suitable tool for experiment conditions with complex and continuous stimuli. Using a publicly available EEG-based emotion database named

DEAP, in which 32 participants watched 40 1-minute video clips with different emotional properties, significant correlations between ISNCs and the averaged subjective ratings were found. Peak correlations were found over left parietal cortex for the arousal dimension (r=0.413, p=0.008), and over anterior frontal region for the valence dimension (r=0.374, p=0.017), respectively. Using the multi-channel ISNCs as features, binary classification accuracies for arousal and valence reached 77.5% and 70%, which are superior to the traditional spectral power based method (44.1% and 48.6%). Our results suggest that the inter-subject neural correlation approach is a promising candidate for investigating human emotion experiences.

P10. PSYCHOLOGICAL REFRACTORY PERIOD EFFECT DIFFERENCE BETWEEN THE TWO DIRECTIONS OF SENSORY DOMINANCE

Chen Jiedan, Wang Huan, Su Wen, Wang Jing,Chen Qi

Center for studies of Psychological Application and School of Psychology, South China Normal University, Guangzhou, China

The interference always exists and cannot be overcome when people attempt to execute two tasks simultaneously or in close succession. The performance of tasks deteriorate especially when people execute the second task, which is known as Psychological Refractory Period effect (PRP effect). It has been well documented that the PRP effect also exists in multisensory dual tasks (e.g. one is visual task and another is auditory, stimulus onset asynchrony is shorter than 300 ms). It remains unknown how to calculate PRP effect of each single trial and whether the extent of PRP effect would be different for different directions of sensory dominance. Therefore, a classical psychological refractory period paradigm is used in our study, in which two equivalent auditory and visual tasks were presented in close succession (the SOA was 300 ms in this study), human participants were required to make responses to each stimulus as soon as possible, regardless of tasks' order. The PRP effect of each trial was calculated by subtracting the response time of the first task from the second task's. Our results suggested that when visual responses preceded auditory responses the PRP effect was significantly greater than vice versa. These results also provided basis for future fMRI study to explore the neural causes of the PRP effect difference between the two directions of sensory dominance.

P11. MULTISENSORY BODY PERCEPTION IN ANOREXIA NERVOSA

Regine Zopf[1], Erika Contini[1], Chris Fowler[2], Naresh Mondraty[2], Mark A Williams[1]

[1] Perception in Action Research Centre & Department of Cognitive Science, Faculty of Human Sciences, Macquarie University & ARC Centre of Excellence in Cognition and its Disorders, Macquarie University, Sydney, Australia; [2] Wesley Eating Disorder Centre, Wesley Hospital, Sydney, Australia

Anorexia Nervosa (AN) patients report body size and shape distortions — experiencing their body as fat while objectively being very thin. The exact cause of these distortions is unclear and specific disturbances in body perception could be involved. Body perception comprises estimating the shape and location of one's body and requires integrating incoming with stored multisensory information. We investigated if and how multisensory body perception is changed in AN. We tested 23 AN patients and 23 healthy controls in the Rubber Hand Illusion (RHI) paradigm. This paradigm involves the presentation of multisensory conflicts (visual-proprioceptive hand location; visual-tactile touch synchrony) to investigate body perception and tease apart the influence of different sensory factors. We employed an action-oriented reaching task to obtain an implicit measure of perceived hand location. We found significant group-differences in shifts of reaching trajectories, indicating that the influence of proprioceptive information on hand location estimates is reduced in AN. Hand location estimates are relatively more biased towards external visual information, and shorter illness durations predicted a larger visual bias in AN. Furthermore, we did not find evidence for changed touch synchrony processing. This finding provides compelling evidence that multisensory body perception is changed in AN. Proprioception could become more unreliable due

to recurrent physical body change, which would be most pronounced around illness onset. Furthermore, malnutrition combined with genetic and developmental factors could disturb multisensory body perception brain networks.

P12. PERIPERSONAL SPACE BOUNDARIES IN A SOCIAL CONTEXT

Lise Hobeika, Marine Taffou, Isabelle Viaud-Delmon

Laboratoire STMS - IRCAM UMR 9912 CNRS UPMC, France

Peri-personal space (PPS) is critical in the adaptation of our social behavior, it is involved in the control of motor action as well as in the protection of the body. Its boundaries are known to be flexible but so far, little is known about the impact of social cognition on its modulations. Here we investigate whether PPS is differently modulated in the presence of another person sharing a common task or in the presence of a non-interactive person. The impact of the presence of another person is tested in two experimental groups: co-presence and shared-action. In each group, we measure participants' PPS extent in the presence of another participant (not interacting or sharing an action) and alone. We use a modified version of Canzoneri et al. (2012) paradigm to measure the extent of PPS with an audiotactile interaction task. Participants are seated side by side. They respond as fast as possible to a tactile stimulus administered on their hand, while task-irrelevant sounds are presented. The sound stimuli are processed through binaural rendering so that the virtual sound sources are looming toward participants from their right and left front hemi-field. Mean reaction times to the tactile stimuli at the different perceived sound distances are compared and used to estimate PPS boundaries. An extension of PPS boundaries during a common task would indicate that PPS is dynamically coded to share a space of co-action, whereas a contraction would point to a division of space between co-actors.

P13. EFFECT OF VIDEO PLAYBACK RATE ON AUDIOVISUAL SPEECH PERCEPTION AS MEASURED BY THE MCGURK EFFECT

Debshila Basu Mallick[1], John F Magnotti[2], Michael S Beauchamp[2]

[1]Rice University, USA; [2]Baylor College of Medicine, USA

A recent innovation in human communication is audiovisual speech viewed in the form of online videos with adjustable playback rates (for instance, students may view online lectures at a faster rate for more efficient consumption). To examine the effect of playback rate on multisensory speech perception, we used the McGurk effect, in which incongruent audiovisual syllables are presented to evoke the percept of a novel third syllable. Eight McGurk stimuli were created and the playback rate was set to either half-normal speed, normal, or twice-normal speed. Subjects (n = 118) were recruited using Amazon Mechanical Turk and viewed ten repetitions of each stimulus at each playback rate. Compared with normal speed, McGurk responses at half-normal dropped by 11%, from 53% to 42% (paired-test, t(109) = -6.9, p = 10-10). Twice-normal speed videos did not change the number of McGurk responses (p = 0.6). We account for these observations using the causal inference model of speech perception (Magnotti et al, 2013). Observers use the delay between the auditory and visual speech to infer whether the cues arise from a single talker and should be integrated (resulting in the McGurk effect) or arise from two talkers and should not be integrated. At slow playback rates, the audiovisual delay is large, leading observers to infer the existence of two talkers and reducing perception of the McGurk effect.

P14. CONVERGING EVIDENCE FROM ECOG AND FMRI FOR AN ANTERIOR-TO-POSTERIOR BOUNDARY IN THE SUPERIOR TEMPORAL GYRUS FOR AUDIOVISUAL SPEECH PROCESSING

Muge Ozker Sertel[1], Daniel Yoshor[2], Michael Beauchamp[2]

[1]University of Texas Health Science Center at Houston, USA; [2]Baylor College of Medicine, USA

During speech perception, visual information from the face of the talker can compensate for noisy auditory speech. We combined neural recordings from electrodes implanted in the brains of epileptic patients (electrocorticography or ECoG) and BOLD fMRI in normal subjects, to examine the neural mechanisms of multisensory speech perception. Subjects viewed audiovisual words with either clear auditory speech (AV) or noisy auditory speech (AnV), identifying the presented words with a button press. In ECoG, electrodes in superior temporal gyrus (STG) responded to words with a burst of high-gamma (70-100 Hz) activity. Electrodes in the anterior STG (n=16) showed more activity for AV speech while electrodes in the posterior STG (n=12) showed more high-gamma activity for AnV speech (Anterior: AV=175±40%, AnV=75±10%; Posterior: AV=80±20%, AnV=120±20%, mean±SEM, RM-ANOVA p=10-5). To verify that the sharp boundary observed was not a result of abnormal brain organization in epileptic patients, we performed the same experiment with BOLD fMRI in healthy subjects. The same anterior-to-posterior boundary in responses was observed (Anterior: AV=0.32±0.02%, AnV=0.22±0.03%; Posterior: AV=0.27±0.03%, AnV=0.32±0.02%, p=10-4). Adding noise to the auditory component of speech resulted in weaker responses in the anterior STG but not in the posterior STG, possibly because the posterior STG receives more visual inputs that compensate for the degraded auditory signals.

P15. ATTENTIONAL SELECTION RELATED TO READING ABILITY IN ATTENTION-DEFICIT/HYPERACTIVITY DISORDER

Encong Wang[1], Meirong Sun[1], Ye Tao[1], Jialiang Guo[1], Li Sun[2], Yan Song[1]

[1]The State Key Laboratory of Cognitive Neuroscience and Learning & IDG/McGovern Institute for Brain Research, Beijing Normal University, China; [2]Peking University Sixth Hospital / Institute of Mental Health, China

Attention-deficit/hyperactivity disorder (ADHD) is a prevalent neurodevelopmental disorder with prominent impairments in directing and sustaining attention. The current study sought to identify the neurophysiological bases of reading difficulty in ADHD, focusing on the relationship between electroencephalographic (EEG) markers of spatial attention and reading ability. EEG data were collected from 76 children with and without ADHD, ages 9–15 years, while they searched for a shape circle target among diamonds. The shape target elicited a smaller N2pc in children with ADHD (n = 38) compared to typically developing (TD) children (n = 36). The smaller N2pc amplitude predicted lower levels of reading ability in children with ADHD. However, for the TD children, the smaller P1 amplitude predicted lower levels of reading ability in TD children. The correlation between N2pc amplitudes and the reading ability in ADHD suggests that the signal of attentional selection may specifically predicts their reading ability. Our findings provide a neurophysiological basis for the subjective reports of reading difficulty in children with ADHD and highlight the importance of spatial attention in higher neurocognitive functions.

P16. MULTISENSORY INTERACTION BETWEEN NOCICEPTION AND VISION IN LIMB-CENTERED PERIPERSONAL FRAMES OF REFERENCE

Camille Vanderclausen, Lieve Filbrich, Andrea Alamia, Valéry Legrain

Université catholique de Louvain, Belgium

In order to adapt behaviors to a potentially damaging threat, it is crucial to coordinate the perception of the location of the threat in external space and that of the location of the potential damage on the body surface. Here, we investigate how a nociceptive stimulus applied to the hand affects the perception of visual stimuli occurring near the hand, placed either near or far from the body trunk according to the anteroposterior axis. In a temporal order judgement task, participants judged which of two visual stimuli had been

perceived first. Each pair of visual stimuli was preceded by one nociceptive stimulus applied on one of the two hands (unilateral) or two nociceptive stimuli, one applied on each hand simultaneously (bilateral). In the bilateral condition, participants judgments were slightly shifted toward the visual stimulus the closest to the trunk. Despite this overall bias for proximal space, results in the unilateral conditions showed that judgments were shifted towards the visual stimuli which occurred near the hand on which the nociceptive stimulus was applied, independently of its position relative to the trunk. These results suggest the existence of cortical representations of each limb that extend slightly from their corporeal boundaries to external space, and which are used as an interface to integrate somatosensory and non-somatosensory information. Depending on the context (e.g., the occurrence of a nociceptive stimulus), these representations could take into account the relative position of the limb in space, instead of a main body reference defined by the trunk.

P17. THE INFLUENCE OF CROSS-MODAL TEMPORAL CORRESPONDENCE OF AMPLITUDE MODULATION RATE ON EEG STEADY-STATE ACTIVITY AND PERCEPTUAL SENSITIVITY OF SIMULTANEOUS AUDITORY AND TACTILE STIMULATION

Justin R Timora, Timothy W Budd

University of Newcastle, Australia

According to the temporal principle of multisensory integration cross-modal temporal correspondence facilitates multisensory integration and enhances perceptual sensitivity to multisensory stimulation. Recent EEG research suggests that the steady-state response (SSR) may provide a measure of cortical oscillatory, a principle mechanism underlying the binding of cross-modal sensory information. The current study examined the temporal principle by exploring how the correspondence of amplitude modulation (AM) rate of acoustic and vibrotactile stimuli influenced perceptual sensitivity to AM depth and the magnitude of the EEG SSR. EEG was recorded in 29 participants during presentation of acoustic and vibrotactile AM stimuli (either 21 or 40 Hz) across three cross-modal temporal correspondence conditions: Unisensory (unimodal AM stimulation): Same AM rate (multisensory AM stimulation at the same AM rate) and Different AM rate (multisensory AM stimulation at the different AM rates). FFT measures were used to examine how the cross-modal temporal correspondence of AM rate influenced the magnitude of SSR activity. In a separate psychophysical session AM depth detection thresholds were estimated using an adaptive psychophysical procedure for the same stimulus combinations. Results revealed that temporal correspondence of AM rate had little influence on the magnitude of SSR activity while the psychophysical results indicated that multisensory AM stimulation led to decreased perceptual sensitivity. The EEG findings suggest that the magnitude of SSR activity may not provide a sensitive measure of temporal correspondence. Surprisingly, the psychophysical results were inconsistent with the temporal principle and suggest that multisensory acoustic and vibrotactile AM stimulation disrupted rather than enhanced perceptual sensitivity.

P18. EFFECT OF SELECTIVE AND DIVIDED ATTENTIONS ON AUDITORY DOMINANCE IN MULTISENSORY INTEGRATION

Aijun Wang, Ming Zhang

Soochow University, China

Auditory dominance refers to that auditory information competes for preferential access to consciousness in multisensory integration. Sound-induced flash illusion is an auditory dominance phenomenon in multisensory integration. Prior studies mostly asked participants to focus on visual single modal. However, in present study, we not only manipulated the modal-based attention (selective attention vs. divided attention) to ask the participants to focus their attention either on visual modal or auditory modal, but also manipulated the task difficulty to investigate the sound-induced flash illusion. The results showed that fission illusion was larger than fusion illusion, and when the participants were initiative to pay attention to the auditory modal, resulting to enlarge the fission illusion,

while it did not influence the fusion illusion. In addition, from the results of reaction times (RTs), regardless of the participants were focused attention on the auditory modal passively or on the auditory modal initiatively, fission illusion was stable, and it was not affected by the attentional resources. The results indicated that, compared with the fusion illusion, the fission illusion was larger, and it was affected by the distributions of attentional resources. In addition, task difficulty was not a factor that could influence the sound-induced flash illusion.

P19. EFFECT OF AMOUNT OF PRACTICE AND PRACTICE INTERVALS ON VISUOMOTOR LEARNING

Chiharu Yamada[1], Yoshihiro Itaguchi[2], Kazuyoshi Fukuzawa[1]

[1]Waseda University, Japan; [2]Sapporo Medical University, Japan

The aim of our study was to investigate how the amount of practice and the practice interval affect learning processes for visuomotor adaptation. We assessed two indices for new formation of long-term motor memory: aftereffects and savings. Participants performed a tracking task with visuomotor rotation for two days. There were four groups, which differed in the amount of practice on Day 1 (20 or 10 sessions) and a practice interval (in consecutive two days or at one-day interval). On Day 2, all of the participants carried out the tracking task for 10 sessions. On Day 1, aftereffects was observed in the 20-session groups but not in the 10-session groups. However, on Day 2, aftereffects appeared only in the 20-session group where they did the task in consecutive two days. In contrast, savings appeared regardless of whether or not they had one-day interval. Savings was greater in the 20-session groups than in the 10-session groups, and the magnitude was not different between two practice interval conditions. These results suggest that saturation learning is important for acquisition of motor skills, supporting previous findings (Yin and Kitazawa., 2001; Krakauer et al., 2005). In addition, the present study suggested that aftereffects and savings reflect different processes of long-term memory for motor learning (Huang et al., 2011; Haith et al., 2015). One-day interval would eliminate what acquired through fast state processes based on repetitive practice, but it is not sufficient to wipe out what has been learned through slow state processes.

P20. GRAVITY MAY INFLUENCE PERCEIVED LINEARLY ACCELERATING VECTION

Meaghan McManus and Laurence R. Harris

York University, Toronto, Ontario, Canada

The otoliths in the vestibular system respond to linear acceleration and also signal head orientation relative to gravity, since gravity itself is an acceleration. This suggests that when gravity is aligned with the direction of motion, such as when lying prone or supine and translating up or down, that some of the gravity acceleration could be misinterpreted as linear acceleration. Here we compared participants' performance in a virtual move-to-target task while they were either standing or lying prone or supine (gravity in the same or opposite direction as the simulated motion acceleration). While wearing an oculus rift (virtual headset), participants saw a projection of a hallway that had a target at varying distances from them (10 - 80m). When the participant was ready the target was removed and they accelerated forward at 9.8m.s-2. The participant pressed a mouse button when they reached the remembered location of the target. The participant traveled to each distance 10 times, and the distances were randomized across participants and between trials. Preliminary results from a within subjects' analysis indicates significant differences between stopping distances for standing compared to the supine and prone conditions. These results suggest that gravity may be partially misinterpreted as linear acceleration in these conditions, and contribute to the difference in performance.

P21. MINIMUM AUDIBLE ANGLE DURING PASSIVE HORIZONTAL ROTATION

Akio Honda[1], Yoji Masumi[2], Yôiti Suzuki[2], Shuichi Sakamoto[2]

[1] Yamanashi-Eiwa College, Japan; [2] Tohoku University, Japan

Sound localization is regarded as a multisensory process: it at least includes hearing and self-motion perception. Recent reports have described that when a sound is presented during head movement, sound localization accuracy is reduced. This reduction puzzles us because the listener's motion is well known to facilitate sound localization. For this study, we used a spinning chair to examine listeners' sound localization acuity during passive horizontal rotation. We particularly measured the minimum audible angles (MAAs) at locations of 0 deg, left and right 30 deg with respect to the listener. Short pink noise bursts (30 ms) were presented successively from two loudspeakers in a circular array (1.1 m radius) with a loudspeaker separation of 2.5 deg. The listener, sitting on a chair at the circle center, was asked to report whether the second (lag) sound came from a source to the right or left of the first (lead) sound. The delay between the onsets of the lead and lag signals was 500 ms. In the chair-still condition (0 deg/s), listeners were asked to keep the head still, but they had no fixing jig. In the chair-rotation condition, listeners were rotated using the spinning chair (5, 10, and 20 deg/s). Results showed that MAA at 0 deg was higher (worse) than at either left or right 30 deg. Furthermore, the rotation speed showed certain effects on MAAs: MAA at 20 deg/s was significantly higher than those at the other speeds. This tendency was observed for all sound source locations.

P22. REINTERPRETING VISUAL MOTION AS SELF-MOTION REDUCES MOTION-INDUCED BLINDNESS

Yasmeenah Elzein, Laurence R. Harris

York University, Canada

In motion-induced blindness (MIB), a salient target seems to visually disappear in the presence of a moving background. We investigated MIB with a moving background that created self-motion perception (vection) and compared the rate of disappearance to the same movement without self-motion perception. We hypothesized that since we are not normally aware of background motion during self-motion, such motion would not induce MIB. A participant-fixed laser spot was presented ~3° from a fixation point on a textured surface attached to the York Tumbling Room (a furnished room that rotates around the observer). The display was viewed either full field or through goggles masked-down to about ±8.5°. The room rotated around the naso-occipital axis (roll) at either 8°/s (slow) or 36°/s (fast) for 150s. Participants reported whenever they felt vection by holding down a mouse button. Similarly, in separate trials participants held down the mouse button whenever the laser spot disappeared (MIB). Spot disappearance was also measured in a non-motion condition to control for Troxler fading. Participants reported 80% more self-motion with a full-field view compared to viewing through goggles and 40% less target disappearances. The remaining disappearances during vection were almost completely accounted for by Troxler fading. This study suggests that the MIB phenomenon occurs at a processing stage after visual motion created by self-motion is removed from the perceptual scene.

P23. SELF-LOCATION DURING OUT-OF-BODY ILLUSION

Kentaro Hiromitsu, Akira Midorikawa

Chuo University, Japan

Self-locatin is a determinate volume in space, normally localized within the bodily boundaries as represented (Blanke & Metzinger, 2009) and is one of the key components of bodily-self consciousness. It is reported that the self-location is disrupted in patients with

out-of-body experiences (OBE). OBEs have been defined as those in which an individual seems to view his/her body and the world from a location outside his/her physical body (Blanke, Landis, Spinelli, & Seeck, 2004). According to these reports, the patients looked down on their body from overhead. The downward perspective has been postulated to arise as a consequence of visuo-vestibular conflict in OBE caused by lesions at the temporo-parietal junction (TPJ), which encodes self-location (Ionta et al., 2011). Based on this phenomenon, we adopted a downward perspective in an experimentally induced OBE paradigm (Ehrsson, 2007) and the self-location mapping (feelings of body drift). The results revealed that there is no significant difference between parallel and downward perspective in the self-location mapping. However, there is a correlation between the sensation of an OBE and self-location under the downward-perspective condition but not under the parallel-perspective condition. Thus, there might be the possibility that the disruption of self-location during experiment is associated with the position of the perspective in space.

P24. BENEFITS OF BIASED AUDIOVISUAL DURATION ESTIMATES

Lina Jia[1], Zhuanghua Shi [2*], Stephanie Ganzenmueller[1,3], Hermann J. Müller[1,4]

[1]School of Humanities, Jiangnan University, China; [2]Department of Psychology, LMU Munich, Germany; [3]Graduate School of Systemic Neuroscience, LMU Munich, Germany; [4]School of Psychological Science, Birkbeck College (University of London), London, UK

Previous studies mainly focused on the integration of audiovisual signals in temporal location. Using a duration bisection task, we directly examined whether the estimate of audiovisual duration with unimodal temporal discrepancies would show an optimal way based on the reliabilities of visual and auditory components. The integration of audiovisual duration was compared in non-noise (Experiment 1) and auditory noise context where the actual reliabilities of auditory and visual estimates were equal (Experiment 2b). Results revealed that both the biased audiovisual estimates (longer than physical values) and their mean precisions were consistent with Maximum-likelihood Estimation (MLE) in two types of contexts. More interestingly, in noise context the mean precision of the audiovisual duration estimates was better than unimodal precision (auditory/visual), showing an optimal way. Our findings offered the direct evidence for how the estimates of visual and auditory duration were integrated. Audiovisual integration was beneficial when unimodal components had equal reliabilities, by reducing error in the two-cue estimate.

P25. AUDITORY SPACE REPRESENTATION ON THE HORIZONTAL PLANE

Aggius-Vella Elena, Campus Claudio, Finocchietti Sara, Gori Monica

Unit for Visually Impaired People, Fondazione Istituto Italiano di Tecnologia, Italy

It is not clear to date whether auditory space representation is different for the upper and lower part of the body. In this work we evaluated the accuracy and precision of 10 sighted subjects in localizing the end point of moving sounds presented in the upper and lower part of the body space when sound trajectory was reproduced with the arm or with the foot. In particular, each subject was standing in the middle of a circumference placed on the floor. On this circumference we placed 6 targets: during each trial, subjects had to localize the endpoint of a sound radially moving from the subject to one of the 6 targets.
Results suggest that the position of the sound may affect the subject response. When the sound was provided on the lower part of the body, we found a bias in the frontal space. Contrarily no bias was observed when the sound was presented in the upper part of the body. Interestingly, the bias was present both whether the sound was reproduced by the foot or by the arm. Furthermore, no difference was present when the sound was delivered in a different spatial position with respect to the effector position (i.e. when the sound was in the lower part and the reproduction made with the arm and the reverse). These results give some inputs about how people integrate sounds coming from different spatial locations. We discuss these data in terms of device development for visually

impaired people.

P26. SPEECH SPECIFIC AUDIOVISUAL INTEGRATION SUPPRESS INDUCED THETA-BAND OSCILLATIONS

Alma Lindborg[1], Martijn Baart[2, 3], Tobias Andersen[1]

[1]Department of Applied Mathematics and Computer Science, Technical University of Denmark; [2]BCBL. Basque Center on Cognition, Brain and Language, Donostia - San Sebastián, Spain; [3]Dept of Cognitive Neuropsychology, Tilburg University, Tilburg, the Netherlands

Audiovisual integration of speech is a well-documented phenomenon with well-established electrophysiological effects on event-related potentials. Recent evidence suggests that audiovisual integration of speech also has an effect on non-phaselocked oscillatory activity as a relative suppression of post-stimulus theta-band (4-8 Hz) activity (Keil et al., 2012, Cerebral Cortex (22), 221–231). Here, we have investigated the role of theta suppression in speech-specific audiovisual integration using data from a previously published study using a sine-wave speech (SWS) paradigm (Baart et al, 2014, Neuropsychologia (53), 115–121). In this study, sine-wave approximations of natural pseudowords dubbed onto videos of a human face uttering the same tokens were presented to an informed and a naive group of performers, perceiving them as speech and non-speech, respectively. We compared time-frequency representations of the EEG recordings between speech mode and non-speech mode subjects. A cluster-based permutation test on the time interval 0 to 500 ms for 4-8 Hz revealed a negative cluster (speech mode < non-speech mode) of frontal and central sensors for the audiovisual congruent ($p = 0.029$) and incongruent ($p = 0.030$) condition separately, and for the pooled audiovisual conditions ($p = 0.015$). The effect cannot be explained by a difference in processing of either the auditory or visual component of the signal, since no significant clusters were found for these conditions. Thus, our results imply that perceiving an SWS stimulus as speech gives similar effects on theta-band oscillations as successful audiovisual integration of natural speech.

P27. DIFFERENTIAL COACTIVATION IN A GO/NO-GO TASK WITH WEAK AND STRONG STIMULI

Katsumi Minakata, Matthias Gondan

Department of Psychology, University of Copenhagen, Denmark

When participants respond to visual and auditory stimuli, response times (RT) are often faster when both stimuli are presented together (redundant signals) relative to RT obtained when presented separately. This effect is known as redundant signals effect (RSE). Race models and coactivation models of information processing have been proposed to explain RSE. To distinguish between the accounts, Miller (1982) derived the race model inequality, which is applied to experiments with redundant signals. In race models, two stimulus components are processed in separate channels. In contrast, coactivation models assume integrated processing of the combined stimuli. Different loci of coactivation have been proposed, including sensory, decisional and motor processing stages. In order to determine whether coactivation is found beyond the level of stimulus detection, a go/no-go task was implemented, which targets the response selection stage of information processing. Participants were given instructions to respond to weak auditory, visual or audiovisual “go” stimuli that were intermixed amongst strong auditory, visual or audiovisual “nogo” stimuli, or vice versa. Only RTs for the strong audiovisual target stimuli ($t_{max} = 8.84$, $p < .001$) were faster than that expected from a race model. For weak target stimuli, results were widely consistent with a race model account ($t_{max} = 1.06$, $p > .10$). Results contradict the inverse effectiveness rule and indicate that the RSE is expressed at sensory stages of information processing when audiovisual stimuli are presented at supra-threshold intensities.

P28. AUDIOTACTILE INTERACTIONS IN THE PERCEPTION OF DURATION

Lia Villanueva, Massimiliano Zampini

Center for Mind/Brain Sciences, University of Trento, Italy

Audition and touch share a number of similarities and interact with one another; however, little is known about their interplay in the perception of temporal duration. In the present study, we investigated whether the temporal duration of an auditory or tactile stimulus could modulate the perceived duration of a stimulus presented in the other modality (i.e., tactile or auditory) in between-participants (Experiment 1) and within-participants (Experiment 2) experimental designs. In 2AFC tasks, participants decided which of a pair of events in a target modality was longer. The simultaneously presented distractor stimuli were presented either with a congruent or incongruent duration from the target. Results showed that both auditory and tactile modalities affected duration judgments in the incongruent condition, decreasing performance in both experiments. In Experiment 1, the tactile modality enhanced the perception of auditory stimuli in the congruent condition, and performance improved when responding to unimodal tactile stimuli than to unimodal auditory ones; however, this enhancement was not found in Experiment 2. To the best of our knowledge, this is the first study documenting audiotactile interactions in the perception of duration, and suggests that audition and touch might modulate one another in a more balanced manner. Finally, preliminary evidence showed that this balanced interaction is kept despite changes in the intensity of the distractor modalities.

P29. IMPACT OF CULTURE ON THE DEVELOPMENT OF EMOTION PERCEPTION FROM FACE AND VOICE

Akihiro Tanaka[1], Misako Kawahara[1], Disa Sauter[2]

[1]Tokyo Woman's Christian University, Japan; [2]University of Amsterdam, the Netherlands

Recent studies have demonstrated cultural differences in multisensory emotion perception from faces and voices. Tanaka et al. (2010) showed that Japanese people are more tuned than Dutch people to vocal processing in adults. The current study investigated how such a cultural difference develops in children and adults. In the experiment, Japanese and Dutch participants observed affective expressions of both Japanese and Dutch actors. A face and a voice, expressing either congruent or incongruent emotions, were presented simultaneously on each trial. Participants judged whether the person is happy or angry. Results in incongruent trials showed that the rate of vocal responses was higher in Japanese than Dutch participants in adults, especially when in-group speakers expressed a happy face with an angry voice. The rate of vocal responses was very low and not significantly different between Japanese and Dutch 5-6-year-olds. However, it increased over age in Japanese participants, while it remained the same in Dutch participants. These results reveal the developmental onset of cultural differences in multisensory emotion perception.

P30. MEASURING THE EFFECT OF SHORT-TERM LIMB IMMOBILIZATION ON MOTOR IMAGERY

Charlotte Verfaille[1], Xavier Libouton[2] & Valéry Legrain[1]

[1]Université Catholique de Louvain – IoNs, Belgium; [2]University Hospital Saint-Luc, Belgium

What happens in the brain following short-term limb immobilization? During the past decade, this question has been broadly investigated from evidence detailing cortical sensorimotor reorganisation [1] to motor performance changes [2]. More specifically, a set of experiments has focused on the influence of upper-limb immobilization on body representation changes concluding on a modification of the hand cognitive representation and its hand motor simulation [3]. This current research is directly in line with the

previous results presented above and has for aim to determine the consequence of a short-term upper-limb immobilization on long term hand cognitive representation. In order to answer this question, we immobilized the left hand of 13 participants with a plaster cast during 72 hours and compared their performance at the Hand Laterality Task to a non-immobilized group. This task is specifically used in order to trigger motor imagery processes and evaluate the body representation. It consisted in the presentation of 16 different hands in term of Hand (Right vs. Left), Orientation (40°, 80°, 120° and 160°) and Rotation (Radial vs. Ulnar). Participants were tested at the beginning of the immobilization and just before removing the cast as well as 72 hours after cast removal. Reaction time results revealed no difference between the immobilized and the control group. Therefore, these outcomes do not support that sensorimotor deprivation following a brief period of immobilization can modify the cortical representation of hand movements.

P31. ASSESSING ACCURACY OF PERCEIVED ARM, HAND, AND PALM SIZE IN HEALTHY PARTICIPANTS

Sarah D'Amour, Laurence R. Harris

York University, Canada

The perception of body size has traditionally been studied using subjective, qualitative measures that assess only one type of body representation - the conscious body image. Previous research has typically focused on measuring the perceived size of the entire body rather than individual body parts, such as the arms and the hands. Here, we present a novel psychophysical method for determining perceived body size that taps into the implicit body representation. Using a two-alternative forced choice (2AFC) design, participants were sequentially shown two life-size images of either their arm, hand, or palm. In one interval either the horizontal or vertical dimension of the image was varied using an adaptive staircase, while the other interval contained the full-size, undistorted image. Participants reported which image most closely matched their own perceived size. The staircase honed in on the distorted image that was equally likely to be judged as matching their perception as the accurate image, from which the perceived size could be calculated. The visual orientation of the image was varied to compare performance for familiar and unfamiliar views. Arm length was significantly overestimated when shown in either horizontal or vertical orientations. Hand and palm size were significantly different from each other and perceived size also depended on the orientation presented. These results indicate that participants' representation of their arms, hands, and palm as longer than actual size and that viewpoint of the part changes perceived size. The method reveals distortions of the implicit body representation independent of the conscious body image.

P32. GALVANIC VESTIBULAR STIMULATION SHIFTS PERCEIVED FINGER ORIENTATION

Lindsey E. Fraser and Laurence R. Harris

York University, Canada

Previously we showed perceived finger orientation in the frontoparallel plane is biased towards an axis ~5° inwards (towards the thumb) for left and right hands. Unpredictable disruptive galvanic vestibular stimulation (dGVS) significantly shifted this bias inward for the left hand only (Fraser & Harris, IMRF 2015). Baseline orientation biases persisted in a non-visual task (judging orientation with respect to gravity vertical), but were not significantly shifted by dGVS. Here, we test perceived finger orientation in the horizontal plane using visual and non-visual tasks. Participants were seated with their pointer finger attached to a motor with their hand pronated parallel to a table surface. A visual probe was projected onto a mirror placed so that the probe was optically superimposed on the participant's unseen hand. The motor rotated their finger to three distractor orientations, followed by a test orientation (10° outwards to 30° inwards in 10° steps). Participants rotated the probe so that it matched perceived finger orientation. In a second study participants judged whether their hand was left or right of "straight ahead" using an adaptive QUEST procedure. Perceived finger orientations were biased towards an axis that was ~25° inwards for the left hand, and ~10° outwards for the right hand. dGVS shifted

biases inwards for both hands. Similar biases were found when “pointing straight ahead” which were unaffected by dGVS. These results suggest proprioceptively judged finger orientation is biased towards a functional task space of the hands. Vestibular disruption appears to alter visual-proprioceptive mapping of the finger.

P33. INVESTIGATING THE ROLE OF WITHIN-PARTICIPANT VARIANCE IN VISUAL-OLFACTORY INTERACTION

Richard Höchenberger[1], Lars T Boenke[2] & Kathrin Ohla[1]

[1]German Institute of Human Nutrition Potsdam-Rehbrücke (DIfE), Psychophysiology of Food Perception, Nuthetal, Germany; [2]Leibniz Institute for Neurobiology (LIN), Systems Physiology of Learning, Magdeburg, Germany

The presentation of redundant target features can improve performance, e.g. shorten response times (RTs) in a detection task. Raab (1962) proposed a model with independent processing channels, in which overlapping RT distributions of different channels yield a distribution with shorter mean RT in the redundant-target compared to the single-target situation. While Raab’s model suggests that shorter mean RT and a decrease of RT variance are both associated with statistical facilitation, most research focused on mean RT, and has neglected variance at large. We explored whether variance yields additional information about multisensory integration. 20 participants performed a speeded detection task with visual (V), olfactory (O), and bimodal visual-olfactory (VO) stimuli. For each participant and modality, we calculated mean RTs and variances and estimated cumulative RT distribution functions (CDFs). Participants demonstrating bimodal facilitation in mean RT (N=15) were divided based on different patterns of variance: group-A showed a reduction of variance compared to unimodal stimulation, while group-B did not. We estimated bimodal RT benefits by comparing bimodal with unimodal CDFs for both groups: relative RT differences between the bimodal and either unimodal CDF were calculated. The resulting difference curves represent the multisensory gains through O (VO-V) and V (VO-O), respectively. Participants profited differently from bimodal stimulation: in group-A, V contributed more to the bimodal RT improvement, while in group-B, O contributed more at most percentiles. These findings suggest that RT variance, additionally to mean RTs, provides information about stimulus processing that exceeds the information that could be extracted from mean RTs alone.

P34. DYNAMIC ADJUSTMENT OF TOOL USE IN A RESPONSE PRIMING TASK IN FIELD HOCKEY - THE ROLE OF EXPERTISE IN TOOL INTEGRATION WITH BODY REPRESENTATIONS

Marten de Man, Lucy Parrington and Lisa Wise

Swinburne University of Technology Victoria, Australia.

During tool-use, the body is functionally extended to incorporate the tool into perceptual and cognitive awareness. This study uses the applied domain of field hockey to explore the degree to which tools are integrated into sensory and motor body representations to support increasing levels of expertise in tool-use ability. Novice versus experienced participants performed a three-choice response-priming task involving two field hockey skills, directly passing a ball to a target and executing a dribble-pass combination. In half the blocks of trials, a cue light appeared above one of the targets somewhere within a 2 sec pre-trial window prior to the target light, generating a No Cue condition, and Valid Cue and Invalid Cue conditions, where the cue and target location were congruent or incongruent respectively. Preliminary data on response accuracy, reaction time and biomechanical movement patterns suggest that for novices, visual information is salient when initiating and monitoring tool-use actions, such that performance was improved by valid cues and disrupted by invalid cues. In contrast, experts were relatively unaffected by the cue, and initiated actions on the identification of the target while perceptually monitoring between the tool (hockey stick), ball and the potential targets. Further data will assist in identifying how previous experience with a tool influences not only how the tool is integrated to the body, but also how the integrated tool generates domain-specific affordances to perform the task. An understanding of the perceptual-cognitive and functional indicators of expert tool-use can assist in developing models for tool-use training.

P35. EXPLORING THE EEG-BASED INTER-SUBJECT NEURAL COUPLINGS DURING NATURALISTIC NARRATIVE SPEECH

Jiawei Li, Dan Zhang

Department of Psychology, Tsinghua University, Beijing, China

Increasing interest has been drawn towards the use of the inter-subject neural coupling (ISNC) approach for studying human cognitive functions, especially in conditions with complex and naturalistic stimuli. Complementary to the conventional event-related methods focusing on response amplitudes and latencies, the ISNC-based methods emphasize the similarity of neural response patterns across different human subjects. In this study, we invited twelve participants to listen to a series of auditorily presented 30-second long narratives from two speakers, with the electroencephalogram (EEG) signals recorded for both the listeners and the speakers. The ISNC across all listeners showed a symmetrically distributed neural coupling pattern covering the fronto-central region as well as the occipital region, which was substantially different from the contralateral parieto-temporal activation pattern elicited by the pure tone control stimuli. More importantly, the listener-speaker ISNC revealed strong couplings over a contralateral frontal region and an ipsilateral parieto-occipital region, relative to the speech stimuli. The listener-speaker couplings were most prominent when the time lag between the two EEG signals was around 2 secs or -2 secs, indicating possible functional roles of the observed coupling for predicting and post-processing of the perceived speech stimuli. Taken together, our results suggest that the EEG-based ISNC as a promising tool for studying human speech functions.

P36. LONG-TERM MUSICAL TRAINING ALTERS THE INTERACTION BETWEEN FRAMES OF REFERENCE

Simon P. Landry; François Champoux

Université de Montréal, Canada

Long-term musical training is an enriched multisensory training environment. It alters sensory substrates and abilities, and has effects on multisensory integration. However, no study has investigated the effects of this multisensory training on sensory frames of reference. The crossed arm temporal order judgement (TOJ) and frame and rod (F&R) tasks are tasks used to measure the ability to integrate sensory frames of reference. These tasks measure the effect of conflicting frame of reference information from tactile and visual input, respectively. In this study, we investigated the effect of musical training on tactile and visual frames of references using a TOJ and F&R task. 14 musicians and 14 controls were recruited. A TOJ task was used in which a conflict is induced between allocentric and egocentric response criteria by crossing the arms. The two groups' average proportion of correct responses (PCD) between crossed and uncrossed postures was compared. The F&R task was used to measure the impact of visual information on subjective direction of gravity. The effect of a visual frame on subjective direction of gravity was compared for both groups. Results from the TOJ task revealed a significant group difference between PCD scores. The performed analysis for the F&R task did not reveal a significant difference between groups. These results suggest that long-term musical training alters the weighing egocentric and allocentric for tactile, but not visual input. Musical training appears to place great importance on tactile information and limb position, thus enhancing the egocentric frame of reference for tactile input.

P37. SACCADIC PREPARATION TRIGGERS VISUAL OSCILLATIONS IN CONTRAST SENSITIVITY

Alessandro Benedetto[1,2] and M. Concetta Morrone[2,3,4]

[1]Department of Neuroscience, Psychology, Pharmacology and Child Health, University of Florence, Florence, Italy; [2] Department of Translational Research on New Technologies in Medicines and Surgery, University of Pisa, Pisa, Italy; [3] Neuroscience Institute, National Research Council, Pisa, Italy; [4] Scientific Institute Stella Maris, Pisa, Italy

Action can profoundly influence perception; one clear case is saccadic suppression, the reduced visibility around the time of saccades [1], another is the oscillatory modulation of visibility synchronized with hand action [2-3]. Here to reveal visual oscillations, we investigated psychophysically the effect of saccades on contrast discrimination sensitivities, measuring the temporal dynamics of visual contrast increment threshold before, during, and after rhythmic saccade execution. Subjects (N=6) made 20° horizontal saccades at will to stationary saccadic target. At a random interval, a brief (10ms) Gabor patch was displayed between the fixations. Subjects were required to detect by 2AFC a contrast increment in either the upper or lower field. We observed that contrast sensitivity fluctuates rhythmical at about 3 Hz, commencing 0.5 second before saccade execution and lasting around 1 second. The results show that saccadic preparation triggers visual oscillations in the delta range. Interestingly, the classical peri-saccadic suppression was systematically embedded in the troughs of these oscillations. We suggest that the corollary discharge signal plays a key role in synchronizing action and perception over long time, helping to optimize visual exploration and to maintain visual stability.

P38. EEG ACTIVITY OF PERCEPTION AND IMAGERY OF VIBROTACTILE STIMULATION

Shusheng Zhang, Yuru Zhang, Xiaojun Xu, Lulu Xu, Dangxiao Wang*

Beihang University, China

When vibrotactile stimulation with constant frequency was exerted on human's skin, brainwave synchronization could be observed, i.e. the Electroencephalography (EEG) signal with same frequency increased. It is unknown whether similar effects exist when human is imaging or recalling a previously experienced vibrotactile stimulus with a particular frequency. In this paper, we measured the EEG activity under perception and imagery of vibrotactile stimuli. Participants received vibrotactile stimulation through their right index finger and then performed tactile imagery tasks by making tactile judgments to discriminate the previously perceived reference stimulus and another test stimulus. The EEG spectrum energy under physical and imaginary stimulation of three different reference stimuli was compared. The results showed that the effect of brainwave synchronization existed during both perception and imagery of stimulation for two of the reference stimuli (i.e. 7Hz and 15Hz sinusoidal vibration), while no significant changes could be observed for the 10Hz reference stimulus. Furthermore, compared to the baseline EEG signal, the energy within the Theta band (i.e. 4-7 Hz) increased during both the perception and imagery stimulation process of all the three reference stimuli. The results implied the possibility of using imagery of vibrotactile stimulation for brain-computer interfaces and neurofeedback training applications.

P39. EARLY CROSS MODAL INTERACTION IN VENTRAL VISUAL CORTEX IS MODULATED BY ATTENTION

Wenfeng Feng[1], Antigona Martinez[2, 3], Aijun Wang[1], Ming Zhang[1] & Steven A Hillyard[3]

[1]Department of Psychology, SooChow University, China; [2]S. Kline Institute for Psychiatric Research, Orangeburg, New York, USA ; [3]Department of Neurosciences, University of California at San Diego, USA

Stimuli of different modalities presented simultaneously or close in time were integrated to form a multisensory object. Audio-visual cross modal interaction were found even before 100ms by previous studies. In the current study, we investigated when and where early cross-modal interaction occurs in human brain and attention effects on it. Event-related potentials were recorded while attention was directed to both modalities on lateral location in Experiment 1 and directed to central Gabor patch of visual modality or lateralized

sound of auditory modality in Experiment 2. The current study for the first time showed an early cross modal interaction revealed by a positivity at 52–84ms localized to ventral visual cortex after eliminating possible confounding. And then a later cross modal interaction revealed by positivity at 160–180ms localized to nearby brain area. These interactions were observed only when both modalities were attended but not unattended in Experiment 1 and only when attended unilateral sounds were presented simultaneously with irrelevant visual stimuli, but not for the same physical stimuli when the sounds were unattended or irrelevant (visual attended) in Experiment 2. However, cross modal interactions at later stages of 184–216ms and 260–312ms arose from superior temporal gyrus were observed in all the conditions of the two experiments. Our results suggest that audio-visual cross modal interactions at 52–84ms and 160–180ms in ventral visual cortex were modulated by spatial attention and auditory attention.

P40. A SYSTEM TO PROVIDE A USER AN ARTIFICIAL OCULOMOTOR FUNCTION TO CONTROL DIRECTIONS OF BOTH EYES INDEPENDENTLY BY ONE HAND

Fumio Mizuno[1], Tomoaki Hayasaka[2] and Takami Yamaguchi[3]

[1]Tohoku Institute of Technology, Sendai, Japan; [2]Graduate School of Biomedical Engineering, Tohoku University, Sendai, Japan; [3]Graduate School of Biomedical Engineering, Tohoku University, Sendai, Japan

Inspired by independent eye movements of chameleon, we have been developing a wearable system to provide independent fields of view to both eyes of a human user. The system is composed of a controller combining 3D sensors and trackballs, two CCD cameras controlled independently and a head-mounted display (HMD). The user can control each tracking directions of two cameras with sensors set to both of hands so that the user can get independent arbitrary fields of view to both of eyes. Images taken by each camera is projected onto each eye independently by using the HMD in real time. We examined human performance while using the system by conducting experimental task of visual search. Results of experiments showed that the user could look around and distinguish independent views although response time as human performance was delayed up to 134.9% on 10 subjects. In previous work, the user had to use both two hands to control the system. This situation is inconvenient to do tasks to touch surrounding environments. Therefore, we designed several control methods and implemented them in the system as functions to control the system with one-hand. The one-handed control is expected to be more complicated than control by both hands and to reduce human performance while binocular rivalry happened to the user. We will investigate the user's performance and optimize the usage of the system in future work.

P41. RUBBER HAND ILLUSION AND PSYCHOSOMATIC PATHOLOGY

Olga Perepelkina

Lomonosov Moscow State University, Russian Federation

The aim of the study was to examine how factors of psychosomatic pathology modulate body awareness. It was previously shown (Grynberg and Pollatos, 2015) that higher levels of alexithymia were associated with a lower ownership illusion. It was also revealed (Miles et al., 2011) that medically unexplained symptom reports were associated with a decreased response to the rubber hand illusion. In this study, we investigated effects of alexithymia and somatoform disorders on the rubber hand illusion (RHI), measured by questionnaire and proprioceptive drift. Subjects underwent RHI and completed Russian versions of Toronto Alexithymia Scale (TAS-20) and Screening for Somatoform Disorders (SOMS-2). No significant correlation between alexithymia scores and factors of illusion (proprioceptive drift and questionnaire) was found. Significant positive correlation was found between test questions in a synchronous condition of illusion, and the total score of the SOMS-2. This suggests that subjects with high scores on a scale of somatoform disorder experience a stronger illusion of rubber hands, than subjects with lower scores. Perhaps it indicates a greater

susceptibility of patients with somatoform disorders to distortion of body perception. Thus, the results of (Grynberg and Pollatos, 2015) were not confirmed in our study. Probably, alexithymia does not directly influence multisensory integration mechanisms. The changes in perception of the illusion may be explained by other variables, i.e. somatoform disorder. So, somatoform disorders may be an additional top-down factor that modulates the RHI. The reported study was funded by RFBR according to the research project No. 16-36-00394 мол_а.

P42. GRASPING AND POINTING VISUAL CONFLICT

Xunbing Shen[1], Xia Shi[2], Xiuying Qian[3]

[1] Jiangxi University of Traditional Chinese Medicine, Nanchang, China; [2] Tianjin University of Technology and Ed, Tianjin, China; [3] Zhejiang University

There had been many debates about the two-visual-systems hypothesis that proposed by Goodale, M.A. and his colleagues which postulated perception and action are separated. Many researchers had provided variety of evidence to support or falsify the hypothesis. For instance, the study performed by Aglioti, et.al seemed to offer a good evidence for the theory, but some following investigations which used a variety of optical illusions including the Ebbinghaus illusion, however, found that there had been no consistent results. The current study employed the conflict or interference in perception to test the theory. We tried to find the effect resulted from perceptual conflicts or interferences which affected subjects' grasping and pointing. There are two experiments, which adopted Stroop、Garner and SNARC paradigm. The participants grasped and pointed the Arabic numerals in a paper panel. The movement of index finger and thumb of the dominant hand were recorded by Mocap (Motion Analysis Inc.) and the maximum grip aperture (MGA) was measured as dependent variable. The results showed that Stroop and Garner interference had no effect, but the interactive effect between Stroop and numeral order (ascending or descending, or SNARC) was significant, and the order of number had significantly affected action. These results indicated that interference or conflict in visual perception had impacts on action. The results suggested that the perception and action, to some degree, were not separated.

P43. VISUAL-HAPTIC DISTANCE PERCEPTION IN THE CENTRAL FOVEA AND PERIPHERY OF THE PERIPERSONAL SPACE

Oscar Javier Ariza Núñez[1], Frank Steinicke[1], Fang Fang[2], Lihan Chen[2]

[1]Human-Computer Interaction, University of Hamburg, Germany; [2]Department of Psychology, Peking University, China

Objects produce quite distinct images in terms of the area on which they are projected in the cortical representation, while the cortical area is significantly larger for objects in the fovea compared to those viewed in the periphery. Previous work by Valsecchi and Gegenfurtner [1] show that perceptual recalibration can occur while objects move across the visual field. Furthermore, Goodale et al. [2] proposed the functional dissociation of perception and action in the framework of dual-routes. In this poster we report about how perception and action is coupled in the peripersonal space for distance estimation task by considering perception and action in the fovea as well as periphery. In our experiments, participants are instructed to report the distance to virtual target objects displayed on the head-mounted display (HMD) by moving a comparison object to a target using their tracked finger. As a baseline, we use a closed-loop scenario in which participants can see a visual hand representation, whereas in the open-loop condition participants do not perceive visual feedback, but only perceive haptic information about their actions. We consider four configurations of the relative position between the target and the comparison: (1) starting point of the comparison and the target location are placed at the central foveal location but vary in depth; (2) starting point of the comparison and the target location are located at the peripheral positions and vary in depth; (3) starting point of the comparison is at the central foveal location while the position of the target is at the peripheral location; (4) starting point of the comparison is at the peripheral location while the position of the target is at the central foveal location.

The result will show how humans perceive the peripersonal space in HMD environment, in particular, when performing actions in- and outside the central fovea. We will present the experiment as well as the results, and will discuss potential applications to HMD tele-operations.

P44. ABSENCE OF AUDITORY INFLUENCE ON FACIAL EXPRESSION ADAPTATION

Sang-Wook Hong[1, 2] & K. Lira Yoon[3]

[1]Department of Psychology, Florida Atlantic University; [2]Center for Complex Systems and Brain Sciences, Florida Atlantic University; [3]Department of Psychology, University of Notre Dame

Prolonged viewing of a facial expression alters perceptual experience of a subsequently presented neutral face to a face with an opposite affect, known as facial expression adaptation aftereffect (FEAAE). Considering that affective processing in everyday life is often multisensory, we hypothesized that emotional voice (prosody) might affect FEAAE. To test this hypothesis, we investigated 1) whether exposure to an emotional voice (by itself or with a neutral face) can alter the perception of a subsequently presented neutral face, 2) whether a congruent emotional voice enhances FEAAE. Participants made judgments (happy or angry, 2AFC) about briefly presented morphed faces (20, 30, 40, 50, 60, 70, 80% morphs between happy and angry faces) after 5-second of adaptations to blank/neutral faces with emotional voices (Exp.1) and to low intensity facial expressions (morphed with neutral faces) with congruent/incongruent emotional voices (Exp. 2). A strong FEAAE was observed when participants were adapted to full intensity facial expressions without auditory input, replicating previous studies. When participants were adapted to emotional voices while viewing either a blank screen or neutral faces, no FEAAE was observed indicating that affective voice alone is not potent enough to induce FEAAE. We also found that the adaptation to the low intensity facial expressions with congruent emotional voices did not induce a significant change in FEAAE, indicating that a congruent emotional voice may not significantly enhance visual signal that mediates FEAAE. Together, our results suggest that FEAAE may occur purely based on visual processing and not be affected by emotional prosody.

P45. AUDIOVISUAL CROSS-MODAL CORRESPONDENCES BASED ON TERNUS DISPLAY

Lu Guo[1], Ming Bao[1*], Lihan Chen [2]

[1]Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, Beijing, China; [2]Department of Psychology, Peking University, Beijing, China

In everyday life, people often show a systematic tendency to associate moving objects with changing pitch, which is one of typical cases of the cross-modal correspondence. Previous studies suggest that sounds with ascending frequency modulation guide visual spatial attention upwards whereas sounds with descending frequency modulation direct attention downwards (Mossbridge et al., 2011). Here, we focused on whether cross-modal correspondence between pitch change and motion direction could influence one's perception towards categorization of visual Ternus display. To achieve this, we juxtaposed auditory pitch-modulated sound with visual Ternus display. A typical Ternus display is composed of two successive frames, each containing two horizontal dots, which can induce either of two different percepts of apparent motion: 'element motion' (EM) or 'group motion'(GM). The Ternus display we used here for experiments was similar to the typical one, while the dots were presented either upwards or downwards in vertical direction. Three audiovisual stimulus condition configurations and a control stimulus configuration (visual Ternus only) were used in the experiment. In the first ('congruent') pattern, ascending frequency and descending frequency relatively corresponded with upward and downward Ternus motion. In the second ('incongruent') pattern, the correspondence between frequency change and motion direction was the opposite to that of the 'congruent' pattern. In the third ('fixed pitch') pattern, the upward or downward motions were both presented with a pure sound of a fixed frequency. The subjects were required to make a perceptual discrimination of Ternus motion in the presence of concurrent auditory stimuli. After the experiment, Embedded figure test was used here to explore the

correlation between the subjects' cognitive styles and their performance in different auditory-visual conditions. In daily life one may have higher sensitivity towards downward motion, so we assume that one may have higher sensitivity under the congruent auditory-visual condition. But current findings fail to prove this hypothesis: the subjects' performances on congruent and incongruent auditory-visual conditions are significantly worse than that on no sound condition.

P46. CORPOREAL CONSTRAINTS ON MULTISENSORY INTEGRATION: EVIDENCE FROM THE MIRROR BOX ILLUSION

Yuqi Liu, Jared Medina

University of Delaware, USA

Are there biomechanical constraints on multisensory integration of the body? We used the mirror box illusion to examine whether the body provides additional constraints on multisensory integration. In Experiment 1, we examined multisensory integration by manipulating postural congruence (palm up versus palm down) and movement synchrony (in-phase versus out-of-phase) between the viewed reflection of the right hand and the hidden left hand. Remarkably, when hand posture was incongruent but movements were synchronous, hidden hand posture was perceived as either the same as the visual estimate or as having rotated towards the visual estimate, demonstrating that synchronous movements can facilitate multisensory integration leading to changes in felt hand posture. If multisensory integration is influenced by biomechanical constraints, integration should be stronger when the rotational distance from the proprioceptively defined to the visually defined posture is shorter and less biomechanically constrained (e.g. rotation of the left hand from "palm inward" to "palm down" is less biomechanically constrained than to "palm up"). To test this hypothesis, we replicated Experiment 1 with only synchronous movements, manipulating angular displacement (0°, 90°, 180°, and 270°) and the amount of biomechanical constraint between the viewed and hidden hand postures. Consistent with our hypothesis, we found that as angular displacement and biomechanical constraints decreased, multisensory integration increased (as demonstrated by higher ownership ratings and more illusory hand rotation). These findings show for the first time that biomechanical constraints are taken into account in multisensory integration of the body and we discuss incorporating these constraints in multisensory integration models.

P47. POSTURAL MODULATION BY (UN)EMBODIED PROSTHETIC ARM

Shu Imaizumi[1,2,3], Tomohisa Asai[2], & Shinichi Koyama[1]

[1] Chiba University, Chiba, Japan; [2] NTT Communication Science Laboratories, Kanagawa, Japan;[3] Japan Society for the Promotion of Science, Tokyo, Japan

Senses of body ownership ("this arm belongs to me") and agency ("I am controlling this arm"), constituting the sense of self, stem from the sensorimotor system. External objects (e.g., prostheses) can be integrated into the sensorimotor system due to long-term use, and recognized as one's own body or effector. We examined how an (un)embodied prosthetic arm modulates whole-body (postural) control, and assessed the components of embodiment of the prosthetic arm. Nine male unilateral upper-limb amputees participated. Four frequently used their prosthetic arm, while the others rarely used it. Postural sway was measured during quiet standing with or without the prosthesis. The frequent users showed greater sway when they removed the prosthesis, while the rare users showed greater sway when they fitted the prosthesis. Frequent users reported greater everyday feelings of postural stabilization by prosthesis and a larger sense of agency over the prosthesis. A follow-up experiment with age- and sex-matched healthy controls confirmed that these postural modulations by a prosthetic arm were not simply due to abnormal postural control in the amputees. We suggest that an embodied prosthetic arm maintains amputees' postural control while an unembodied arm perturbs it, and prosthetic embodiment is likely to involve the sense of agency rather than ownership.

P48. INTEGRATION OF VISUAL AND TACTILE INFORMATION IN PROCESSING OF SELF-MOTION

Jan Churan, Johannes Paul, Frank Bremmer

Department of Neurophysics, University of Marburg, Germany

During locomotion in a natural environment, various sensory signals can be used to determine critical parameters of self-motion. Visual and vestibular signals have been shown to contribute to a precise representation of heading. The role of tactile flow has not yet been determined. We tested the ability of human subjects to utilize visual and tactile information to accurately reproduce a simulated traveled distance. In a first set of trials, subjects first experienced a bi-modal simulated forward translation. We found that the subjects were able to reproduce distances based on the information of each single modality with similar accuracy and precision. With feedback from both modalities, accuracy increased slightly but less than predicted by optimal integration. In a second set of experiments we investigated an effect of rescaling, i.e. a 25% increase or decrease of tactile flow, which were both unnoticed by our subjects. We found a significant effect of rescaling on the reproduced distance suggesting that information of the two sensory modalities was indeed integrated. Interestingly, when we switched the polarity of the tactile stimulus in that slow tactile motion was associated with fast visual motion and vice versa, we found no effect of rescaling. Accordingly, in this case tactile information was not integrated with visual information. We conclude that for a successful integration of sensory information from different modalities, these signals not only have to be informative, but also ecologically congruent. This finding is in line with neurophysiological data from the animal model, i.e. the macaque monkey.

P49. INTERACTIONS BETWEEN PHYSICAL AND SEMANTIC TEMPERATURE

Yizhen Zhou, Hsin-Ni Ho, Junji Watanabe

Department of Information Processing, Tokyo Institute of Technology, Japan

Classical theories assume that meaning arises from the combination of symbols which have little connection with the external physical world. However, recent studies challenged it with the alternative theories, the “embodied” or “grounded” models, which suggest that semantic processing is grounded in representations of actual objects and physical environments. A well-known set of findings from the grounded cognition is focused on the interaction between sentence processing and visual/auditory perception. Although there are previous researches revealing the semantic interference and facilitation in haptic perception such as weight, the empirical demonstration of grounding semantics of language in haptics is still insufficient especially in thermal sensation. In order to determine the strength of semantic association between thermal sensations and their lingual descriptions, we performed experiments of speeded target categorisation for the thermal quality, “hot” and “cold”, while presenting physical thermal stimulation to the participant. The target stimuli were shown in the form of semantic words, illustrative figures, and auditory recordings. The results suggested that the experience of physical temperature facilitated the internal processing of meaning, the response latencies of congruent conditions were faster than incongruent ones.

P50. NEURAL CORRELATES OF AUDITORY-TACTILE INTEGRATION

Juan Huang[1], Tianxu Wu[2], Xiaoqin Wang[3]

[1] Johns Hopkins University; [2]Tsinghua-Johns Hopkins Joint Center for Biomedical Engineering Research and Department of Biomedical Engineering, Tsinghua University, Beijing, P.R. China; [3] Department of Biomedical Engineering, The Johns Hopkins University, Baltimore, Maryland

Previous studies have shown that concurrently presented auditory and tactile stimulation can be perceptually integrated by human subjects. A recent study from our lab has provided evidence of auditory and tactile integration in music meter perception. How the brain accomplishes this integration remains mostly unknown. In this study, we examined the neural correlates of auditory and tactile integration in music meter perception. Electroencephalogram signals (EEG) were recorded from 15 human subjects while they were presented with uni-modal auditory, uni-modal tactile, or auditory-tactile bi-modal music note sequences. Event related potentials (ERPs) and steady-state evoked responses (SSERs) were analyzed according to different note types and trial conditions. Results showed that the ERP components corresponding to bi-modal conditions have significantly stronger power and shorter latency comparing with uni-modal conditions, indicating that the brain can integrate music meter information when it's presented separately in auditory and tactile modalities. In addition, when a stimulus sequence contained meter structure, the SSERs reflecting the rhythm frequency was significantly enhanced in bi-modal conditions than in uni-modal conditions. Such bi-modal enhancement in SSERs was not observed in random sequences with the same rhythm frequency but without meter structure. Meanwhile, the phase coherence of SSERs was greater in bimodal auditory condition than in uni-modal auditory condition. In summary, this study shows that the auditory-tactile integration significantly enhances the neural processing of temporal sequences with a pattern or structure. These findings help further understand how the brain processes temporal patterns of sensory inputs and performs multi-modal integration.

P51. INTER-TRIAL VARIABILITY OF MCGURK-EFFECT REVEALS MULTI-LEVEL NEURO-MARKERS OF MULTISENSORY SPEECH PERCEPTION

Vinodh Kumar

National Brain Research Centre, India

Observable lip movements of the vocalizer influences perception of auditory speech. A classical example of this influence is reported by listeners who perceive an illusory speech sound (McGurk-effect) when presented with incongruent audio-visual(AV) speech stimuli. Recent neuroimaging studies of AV speech perception accentuate the role of frontal, parietal and the integrative brain sites in the vicinity of the superior temporal sulcus (STS) for speech perception. However, when and at what level of organization do such networks emerge is an open question. We posit that a large scale functional connectivity among the neural population situated in the aforementioned brain sites may provide valuable insight involved in processing and fusing of AV speech. Varying the psychophysical parameters in tandem with electroencephalogram (EEG) recordings, we exploited the trial-by-trial perceptual variability of incongruent audio-visual (AV) speech stimuli to identify the neuro-markers of AV integration that facilitates a specific perceptual experience. We show that a neurocognitive component as early as 120 ms post stimulus onset as a potential marker for multisensory perception. We also demonstrate multisensory perception is likely to be associated with an increased beta (16-30 Hz) and gamma (30-45 Hz) band post stimulus activity. At large-scale network level we show an enhancement in global coherence in beta and gamma bands exclusively during multisensory perception indicating global functional connectivity among candidate brain regions. Together, we report a multi-level representation of task relevant activity in the temporal, spectral and at network level, capturing the complex neuronal mechanisms underlying multisensory speech perception.

P52. COMPENSATORY RECOVERY AFTER MULTISENSORY STIMULATION IN PATIENTS WITH VISUAL FIELD DEFECTS: BEHAVIORAL AND NEUROPHYSIOLOGICAL COMPONENTS

Paolo Antonino Grasso[1], Caterina Bertini[1], Lisa Cipolotti[2], Elisabetta Làdavas[1]

[1] Department of Psychology - University of Bologna, Italy; [2] National Hospital for Neurology and Neurosurgery, University College London, UK

Patients with visual field defects (VFD) have shown preserved multisensory integrative abilities in the blind field (i.e., crossmodal blindsight), likely subserved by the spared retino-colliculo-dorsal pathway. Accordingly, audio-visual integrative mechanisms could be used to increase the functionality of the spared circuit and might represent an important tool for the rehabilitation of VFD. This study tested this hypothesis, investigating whether exposure to systematic audio-visual stimulation could induce long-lasting visual improvements in patients with VFD. Ten patients with chronic VFD were exposed to audio-visual training (4 hours/daily, over 2 weeks). Behavioral, oculomotor and electroencephalography (EEG) measures were recorded during several visual tasks before and after training. After training, improvements in visual search, visual detection, self-perceived disability in daily life activities and oculomotor parameters were found, suggesting the implementation of effective visual exploration strategies. At the electrophysiological level, after training, patients showed a significant reduction of the P3 amplitude in response to stimuli presented in the intact field, reflecting a reduction in attentional resources allocated to the intact visual field, which might co-occur with a shift of spatial attention towards the blind field. More interestingly, both the behavioral and the electrophysiological changes observed after training were stable at a follow-up session (on average, 8 months after training), suggesting long-term effects of multisensory audio-visual training. These long-lasting effects seem to be subserved by the spared retino-colliculo-dorsal pathway, promoting orienting responses towards the blind field, able to both compensate for the visual field loss and concurrently attenuate visual attention towards the intact field.

P53. PREFERENCE FOR VISUAL MOUTH MOVEMENTS PREDICTS AUDITORY RESPONSE IN HUMAN SUPERIOR TEMPORAL SULCUS

Lin L. Zhu, Michael S. Beauchamp

Baylor College of Medicine, USA

Speech perception is a multisensory process that uses both visual information from the talker's face and auditory information from the talker's voice. The superior temporal sulcus (STS) is a key brain locus for multisensory integration but little is known about its neuroanatomical organization. Previous studies have shown that subregions of the STS respond to visually-presented mouth movements, visually-presented eye movements, and auditory stimuli. We hypothesize the existence of a relationship between these different axes of selectivity. Because visual mouth movements are a necessary prerequisite for vocal production, we hypothesized that regions of the STS with a preference for visual mouth movements should respond strongly to auditory stimuli. To test this hypothesis, we used blood oxygenation level dependent (BOLD) functional magnetic resonance imaging (fMRI) to scan twenty subjects. In each subject, we identified STS voxels that showed a preference for visual mouth movements. These voxels showed a greater response to auditory speech than eye-movement preferring voxels (1.4±0.2% vs. 0±0.1%, p=3.8x10−10) with a positive correlation between mouth-preference and auditory response (m=0.22, r2=0.77, p=0.009). Next, we examined whether the auditory response was selective for vocal stimuli. Mouth-preferring voxels responded more to vocal than non-vocal stimuli (1.2±0.1% vs. 0.5±0.1%, p=5.9x10−6) with a correlation between mouth-preference and vocal-preference (m=0.18, r2=0.96, p=1.3x10−4). Our study demonstrates that subregions of the STS respond strongly to both visually-presented mouth movements and auditory speech, suggesting that these stimulus features are coded together in small populations of STS neurons.

P54. GENETICALLY MEDIATED DIFFERENCES IN THE MCGURK EFFECT — A MULTISENSORY SPEECH ILLUSION

Guo Feng[1], Wen Zhou[1], Michael S. Beauchamp[2]

[1]Institute of Psychology, Chinese Academy of Science, China; [2]Department of Neurosurgery and Core for Advanced MRI, Baylor

College of Medicine, USA

Multisensory integration of auditory and visual speech facilitates human communication. A sensitive assay of this integration is the McGurk effect, an illusion in which incongruent visual speech information dramatically changes the percept of auditory speech. Recent research has revealed substantial variability in the McGurk effect, with some subjects never perceiving the illusion and others always perceiving it. However, the source of this variability is unknown. To examine if genetic factors play a role, we measured the McGurk effect in 73 monozygotic (MZ) twin pairs and 89 dizygotic (DZ) twin pairs, retesting a subset of the pairs two years later. The best-fitting genetic model attributed 29% of the variance in the perception of the illusion between individuals to additive genetic factors. The results point to a previously unknown link between genes and multisensory speech perception, an important brain function at the boundary of perception and cognition.

P55. TACTILE AND VISUAL PROCESSING DURING THE RUBBER HAND ILLUSION - AN EVOKED POTENTIALS STUDY

Isa Shashikala Rao & Christoph Kayser

Centre for Cognitive Neuroimaging, Institute of Neuroscience and Psychology, University of Glasgow, UK

The rubber hand illusion (RHI) is used to induce the illusory feeling of ownership over a rubber hand through congruent multisensory stimulation. Thus, it can grant insights into how the brain resolves situations of conflicting multisensory information regarding the body's position. To examine how dynamic changes in bodily consciousness caused by this resolve impact on sensory perception and multisensory integration we acquired multichannel EEG of 13 participants during a modified RHI paradigm. Using a vibration pad on the participant's hand and an LED of similar size on the rubber hand, we acquired evoked potentials registered to the onset of visual and tactile stimulation during four conditions. Visual and tactile stimulation was either synchronous with an anatomically congruent (illusion condition) or incongruent (no illusion condition) placed rubber hand, or unisensory in the absence of the rubber hand. In addition, visual and tactile unisensory conditions were used to identify time points and electrodes of interest. Significant differences emerged in fronto-central areas in the tactile P200 component with the illusion condition showing an amplified response compared to the no illusion condition. In contrast to this, the visual P1 component showed a reduced response in the illusion condition compared to the no illusion condition. These findings suggest that changes in bodily consciousness affect evoked responses to visual and tactile stimuli in distinct ways. Our results also show that more specific control conditions are needed to rule out potential confounds by attention and by the position of the visual stimulus in relation to the body.

P56. NEURAL CORRELATES OF PERCEPTUAL WEIGHTS DURING AUDIO-VISUAL INTEGRATION

Stephanie C. Boyle, Stephanie Kayser & Christoph Kayser

Centre for Cognitive Neuroimaging, Institute of Neuroscience and Psychology, University of Glasgow, Glasgow, United Kingdom.

We investigate the neural mechanisms underlying audio-visual cue integration by combining a rate discrimination task with EEG, cue integration models and multivariate classification methods. Subjects' judged the stimulation rate of auditory, visual, and audio-visual stimuli that varied in rate (8 to 15 Hz, 900ms duration), congruency, and reliability of the visual stimulus while brain activity was recorded using EEG. To calculate behavioural weights for each modality, we regressed behavioural choice against cumulative auditory and visual stimulation rate. This revealed strong weights that changed with reliability early in the trial (<400ms), and that correlated ($r=0.61$, $p<0.05$) with perceptual weights derived from subjects' psychometric curves. To determine neural weights associated with auditory and visual stimuli, we used single-trial linear discriminant analysis to extract the neural component that best discriminated between stimulation rates. We found strongest discrimination accuracy (61%) early in the trial (225ms) and scalp activity

components over fronto-central electrodes. We then regressed single-trial activity of this decoding component against the auditory and visual rates at each time point. Neural weights were also strongest early in the trial (100-300ms), and there was higher auditory weighting when the visual reliability was low. Finally we tested for a relationship between behavioural and neural weights by correlating the two at each time point. This revealed significant (at $p<0.05$) results during three time windows (430:470ms, 570:590ms and 720:815ms). These results show that we can uncover significant neural correlates of behavioural weights early during audio-audiovisual integration, and that both behavioural and neural weights change with sensory reliability.

P57. IS THERE MULTISENSORY INTEGRATION FOR THE ONLINE CONTROL OF VOLUNTARY ACTION?

Luc Tremblay, Darrin Wijeyaratnam, John de Grosbois, Stephen Bested, Rachel Goodman, Valentin Crainic

University of Toronto, Canada

Both vision and proprioception are thought to contribute to the control of ongoing limb trajectories via multiple processes (e.g., Bagesteiro et al., 2006; Elliott et al., 2010; Tremblay et al., 2013). According to Elliott et al. (2010), online control mechanisms require the use of both vision and proprioception, which should result in increased importance of vision and proprioception at some point during a movement. In contrast, it has also been argued that vision and proprioception contribute to different aspects of the trajectory (e.g., Bagesteiro et al., 2006: vision primarily contributes to controlling movement distance whereas proprioception can be used later in the trajectory, to implement online corrections). However, no known investigations of online control mechanisms have directly manipulated the reliability of proprioceptive feedback in neurologically intact individuals. To directly test for the importance of vision and proprioception for the online control of reaching movements, the current study implemented: 1) a dual-muscle between-trial tendon vibration manipulation on one of two blocks of trials, and 2) vision occlusion during the movement on 50% of the trials. The proprioceptive perturbation only yielded significant endpoint biases. In contrast, vision occlusion also yielded increased endpoint variability and more evidence of online trajectory amendments. While proprioception was important to determine the ultimate movement endpoint, only vision appeared to significantly contribute to the online control of reaching movements. As a result, it is worth further investigating if multisensory integration takes place for the online control mechanisms of voluntary movements.

P58. CONNECT THE DOTS: BRAILLE LEARNING IN SIGHTED IMPROVES HAPTIC OBJECT RECOGNITION

Furat AlAhmed, Christian Wallraven

Korea University, Republic Of Korea

Tactile stimulation has been proven to increase haptic performance in different types of perceptual tasks. Results have demonstrated, for example, a positive effect on haptic acuity and object recognition as a result of simple, electric stimulation to the fingers. To date, not much is known about how tactile stimulation that people may be exposed to as part of everyday learning activities may play a role in haptic performance. Here, we test the impact of English Braille learning as a means of providing tactile stimulation on different types of haptic tasks. Eleven sighted undergraduate students were recruited from Korea University to participate in a 4-week program of English Braille learning. In addition to the (successful) Braille learning, we conducted three haptic control tasks before and after the training. In a difficult object similarity-rating task, we found a significant improvement after Braille training, whereas no improvement was found in a haptic pattern matching task or a tactile roughness rating task. Our results confirm that Braille training has a positive impact on an unrelated haptic perceptual task. Such training may also relate to findings in which blind people have improved haptic perception compared to sighted, and may indicate that regular tactile stimulation would even provide the sighted with a more efficient multisensory representation of touch.

P59. REWARD INTERACTS WITH MODALITY SHIFT IN REDUCING CROSS-MODAL CONFLICT

Guanlan Kang[1], Lihui Wang[1], Xiaolin Zhou[1, 2, 3, 4]

[1]Center for Brain and Cognitive Sciences and Department of Psychology, Peking University, Beijing, China; [2] Key Laboratory of Machine Perception (Ministry of Education), Peking University, Beijing, China; [3] Beijing Key Laboratory of Behavior and Mental Health, Peking University, Beijing, China; [4] PKU-IDG/McGovern Institute for Brain Research, Peking University, Beijing, China

Previous studies have shown that reward can enhance cognitive control and reduce conflict in visual processing. Here we investigate: 1) whether/how reward influences cross-modal conflict control, and 2) how the shift of attention across modalities modulates the effect of reward on cross-modal conflict control. In four experiments, a cue indicating reward availability of a given trial (reward vs. no-reward) was presented prior to a target. In reward trials, participants received a certain amount of monetary reward if the response times were faster than the baseline measured previously. The target could be either a visual or an auditory letter, which was accompanied by a distracting stimulus from the other modality. The identity of the distractor was either the same as or different from the identity of the target (congruent vs. incongruent). When the cue modality was constant (Experiments 1 and 2), or changed across different experimental blocks (Experiment 3), the interference effect (i.e., RTs in incongruent trials minus RTs in congruent trials) was smaller following a reward cue than following a no-reward cue, suggesting that reward could reduce cross-modal conflict. By contrast, when the modality of the cue was unpredictably changed trial-by-trial (Experiment 4), reward reduced cross-modal conflict only when the cue modality was different from the target modality. This pattern was replicated in Experiment 5 in which the SOA between the cue and the target was manipulated. These results suggested a flexible reward-driven modulation on cross-modal conflict control.

P60. TRACKING ACOUSTIC FEATURES OF SPEECH IN EARLY BLIND INDIVIDUALS USING MEG

Markus J. van Ackeren, Francesca Barbero, Stefania Mattioni, Roberto Bottini, Olivier Collignon

University of Trento, Italy

Previous studies have demonstrated that occipital areas in blind individuals robustly respond to auditory information up to the level of language comprehension. What features of speech does occipital cortex code for exactly? Using magnetoencephalography (MEG) we investigated if, and at what level (e.g., phonemes syllables, or words) occipital and temporal cortices in the blind entrain to rhythmic acoustic features of speech. We tested early blind and sighted individuals while participants listened to segments from audio books with different levels of spectral distortion. Computing coherence between the speech envelope and the MEG signal we find that neuronal populations in auditory cortex follow the speech rhythm at a temporal scale corresponding to the syllabic rate in our speech stimuli. Strikingly, in blind individuals as compared to sighted controls speech tracking was also observed in the occipital cortex, with early visual cortex showing the highest sensitivity to speech. Our results provide a novel way to address how occipital areas in the blind contribute to speech comprehension by demonstrating that occipital cortex of blind individuals is sensitive to speech down to the level of rhythmic acoustic properties, such as the syllabic rate.

P61. A CAUSAL INFERENCE MODEL EXPLAINS PERCEPTION OF THE MCGURK EFFECT AND OTHER INCONGRUENT AUDIOVISUAL SPEECH

John F. Magnotti and Michael S. Beauchamp

Baylor College of Medicine, USA

Audiovisual speech integration combines information from auditory speech (talker's voice) and visual speech (talker's mouth movements) to improve perceptual accuracy. However, if the auditory and visual speech emanate from different talkers, integration decreases accuracy. Therefore, a key step in audiovisual speech perception is deciding whether auditory and visual speech have the same source, a process known as causal inference. A well-known illusion, the McGurk Effect, consists of incongruent audiovisual syllables, such as auditory "ba" + visual "ga" (AbaVga), that are integrated to produce a fused percept ("da"). This illusion raises two fundamental questions: first, given the incongruence between the auditory and visual syllables in the McGurk stimulus, why are they integrated; and second, why does the McGurk effect not occur for other, very similar syllables (e.g., AgaVba). We describe a Bayesian model of causal inference in multisensory speech perception (CIMS) that predicts the perception of arbitrary combinations of auditory and visual speech. We applied this model to behavioral data collected from 265 subjects perceiving both McGurk and non-McGurk incongruent speech stimuli. The CIMS model successfully predicted both the audiovisual integration observed for McGurk stimuli and the lack of integration observed for non-McGurk stimuli. An identical model without causal inference failed to accurately predict perception for either form of incongruent speech. The CIMS model provides a computational framework for studying how the brain performs one of its most important tasks, integrating auditory and visual speech cues to allow us to communicate with others.

P62. A NEW MEASURE OF MULTISENSORY INTEGRATION

Hans Colonius, Adele Diederich

[1] Oldenburg University, Germany; [2]Jacobs University Bremen, Germany

A single neuron is categorized as multisensory if there is a statistically significant difference between the mean responses evoked by a cross-modal stimulus combination and that evoked by the most effective of its components individually. The most widely used quantitative index expresses multisensory enhancement (or inhibition) as a proportion of the strongest unisensory response. Despite its descriptive value, this index is mute with respect to the possible operations a neuron may perform in combining unisensory inputs to yield the multisensory response. In particular, being responsive to multiple sensory modalities does not guarantee that a neuron has actually engaged in integrating its multiple sensory inputs rather than simply responding to the most salient stimulus. In complete analogy to the race model inequality test routinely applied to testing reaction time facilitation in behavioral studies, here we suggest an alternative measure for single neuron data based on probability summation. The new index compares the mean observed cross-modal response of a neuron with the largest cross-modal mean achievable by stochastically coupling its unisensory responses. Computation of the new index is straightforward and, while being as amenable to statistical testing as the traditional one, it is also sensitive to changes in response variability. Because it is, in general, more restrictive than the traditional one, many neurons previously categorized as multisensory may possibly lose that property. The approach is illustrated by 84 recordings from 20 cells (Wallace lab). We will report bootstrapped confidence intervals for the difference between the new and the traditional measure with and without removing spontaneous activity.

P63. AUDITORY-VISUAL INTEGRATION IN THE POSTERIOR CINGULATE CORTEX OF THE MACAQUE MONKEYS

Cécile Juan, Pascal Girard, Amirouche Sadoun, Lionel Nowak and Céline Cappe

Centre de recherche Cerveau et Cognition, Centre National de la Recherche Scientifique, Toulouse, France

In natural scenes, one should encode where dangers and attractive things are to be able to navigate appropriately. The role of the

posterior cingulate cortex (PCC) is not fully understood but it could be implicated in the spatial learning of emotional stimuli, because of connections with anterior thalamus, amygdala and hippocampus. As natural stimuli are mostly multisensory, we hypothesized that the PCC could integrate multisensory information of emotional stimuli. This hypothesis is in accordance with connections of this area with the superior temporal sulcus. The present work aims at studying the sensory responses of neurons in the PCC of the macaque monkey. Two adult rhesus macaque monkeys were trained to perform a fixation task. We used auditory, visual and auditory-visual natural stimuli consisting of conspecifics, snakes and neutral stimuli (white noise). All auditory-visual stimuli were congruent. To localize the PCC, we compared MRI scans of the monkeys with Logothetis and Paxinos brain atlases, using anatomical markers. After implantation of the recording chamber, we confirmed 3D stereotaxic coordinates of the target area. We recorded the activity of more than 200 single units and local field potentials in the PCC. Preliminary analysis showed that most neurons were selective to multisensory stimuli and some of them were selective to snake stimuli. This study shows first neuronal evidence of the visuo-auditory integration in the PCC of awake monkeys. These stimuli could be treated later as spatial markers to avoid or direct to when the animal explores its environment.

P64. BEHAVIOR AND ERP STUDY OF CROSSMODAL SOURCE IDENTIFICATION OF VOICES AND FACES

Shanshan Guo, Zhongqing Jiang

School of Psychology, Liaoning Normal University, Dalian, China; Liaoning Collaborative Innovation Center of Children and Adolescents Healthy Personality Assessment and Cultivation, China

In order to investigate people's ability of matching unfamiliar person's face and their voice, we presented participants a series of spoken sentence, each one was followed by a face photo. The sentence was either spoken by the person shown as the photo followed, or by the other person, so as to constitute congruent and incongruent conditions. The number of congruent and incongruent trials was matched. The participants didn't know the persons being recorded as experimental materials. Participants were required to judge whether the face and the previous voice belong to one person. The behavioral data showed the test accuracy rate was significantly above random probability ($p < 0.01$); ERP data showed that congruent conditions compared to incongruent conditions, elicited a larger positive component in the time window of 650ms-800ms in the prefrontal lobe; while incongruent conditions compared to congruent conditions within the time window of 300ms-500ms induced a more negative components in the prefrontal lobe of left hemisphere. The study reveals that participants have the ability to match voices to static faces, and we infer that there is an inherent relation between specific voices and faces, which has the characteristics of natural selection and evolutionary significance.

P65. ATTENTION BIAS OF AVOIDANT INDIVIDUALS TO ATTACHMENT EMOTION PICTURES

Ying Liu[1], Xu Chen[12], Yi Ding[1]

[1]Attachment Research Lab, Faculty of Psychology, Southwest University, Chongqing City, 400700, China; [2]Key Laboratory of Cognition and Personality(SWU), Ministry of Education,
Chongqing, 400700, China

How does attachment affect one's emotion process is tightly connected with individuals' attention bias to attachment emotion. However, much conflict still exists in avoidant individuals' attention bias to different emotion, especially for emotion with different valence and different attachment relationship, and few studies provided neural evidence to explain it. The current study examined the neural basis of attention bias to attachment-related pictures of 16 avoidant subjects compared with 17 secure subjects by using the cue-target paradigm. Behaviorally, avoidant individuals had slower reactions than secure individual. No difference of attention components occurred but for considering different attachment relationships, avoidant individuals showed attentional disengagement

to negative parent-child images while secure individuals showed disengagement to positive parent-child images. It can be assumed that parent-child attachment stimuli can arouse one's attachment system more effectively. fMRI results showed that brain activation of avoidant individuals was stronger than that of secure group in superior temporal gyrus, cingulate gyrus, supplementary motor area and middle frontal gyrus. Avoidant individuals also showed stronger bilateral fusiform gryus activation in attentional engagement to negative emotion and attentional disengagement to positive emotion. These findings suggest that avoidant individuals devoted more facial recognitive resources to achieve attentional engagement to negative attachment emotion and need more efforts to get rid of positive attachment emotion. These interesting finding can provide a biomarker of ground-breaking in avoidant individuals' attention bias and inspire us with a new angel of view to research adult attachment.

P66. HEALTH-RELATED AND SKILL-RELATED COMPONENTS: PREDICTORS OF 100M SPRINT PERFORMANCE

Eva Marie Mohametano Ebardo

College of Sports Physical Education and Recreation, Mindanao State University, Marawi City, Philippines

This study revolves on the relationship and extent of relationship between the Health-Related Components (HRC) and the Skill-Related Components (SRC) [Physical Fitness Components] and the 100m Sprint Performance. The HRC include: body composition, cardiovascular endurance, flexibility, muscular endurance and muscular strength, while SRC include: agility, balance, coordination, power, reaction time and speed. It is a complete package and focuses on all of the Physical Fitness Components as the parameters to predict 100m Sprint Performance. The study was conducted at Mindanao State University, Marawi City, Philippines, during the 1st semester, AY 2015-16. Standardized physical fitness tests were employed in obtaining the data and included were 59 male PE4-Athletics students selected through total sampling procedure. The analytical methods utilized were correlation (r) and determination (r2) analyses. Among the HRC, only Muscular Strength was insignificantly related to 100m Sprint Performance. But Cardiovascular Endurance, Body Composition, Muscular endurance, and Flexibility revealed significant relationship and consecutively shared 36.60%, 16.32%, 9.55 %, and 7.08% of the 100m Sprint Performance. While among the SRC, Balance and Reaction Time showed no significant relationship to 100m Sprint Performance. However, Speed, Power, Agility, and Coordination inclined significant relationship and contributed 63.36%, 22.85%, 17.72%, and 12.18% of 100m Sprint Performance; consecutively. In descending order of predictive accuracy: Speed, Cardiovascular Endurance, Power, Agility, Body Composition, Coordination, Muscular endurance, and Flexibility are predictors of 100m Sprint Performance.

P67. FITNESS COMPONENTS: PREDICTORS LONG JUMP PERFORMANCE

Gil Martinez Ebardo

College of Sports Physical Education and Recreation, Mindanao State, University, Marawi City, Philippines

This research aimed to look into deeper analyses of relationships and extent of relationships between the Fitness Components of cardiovascular endurance, flexibility, muscular strength, muscular endurance, body composition [Health-Related Components], agility, balance, coordination, speed and power [Performance-Related Components] and the long jump performance. The study also hoped to establish pertinent information and knowledge which of the Fitness Components are best predictors of long jump performance that could lead in developing meaningful training programs for long jump.The study was conducted at Mindanao State University, Marawi City, Philippines, during the 2nd semester, AY 2014-2015. Included were the 63 samples out of 74 male PE 4 [Athletics] students selected through stratified and systematic random sampling procedures where standardized fitness tests were employed in obtaining data. The relationship between variables was analyzed using Pearson Correlation Coefficient. The extent of relationship between variables was obtained using Coefficient of Determination. Moreover, the stepwise multi-linear regression was reinforced to determine

the minimum and the most effective set of predictors for any criterion. Flexibility, balance, and body composition were insignificantly related to long jump performance. Conversely; agility, muscular strength, power, cardiovascular endurance, speed, muscular endurance and coordination disposed significant correlation and consecutively shared 33.29%, 29.90%, 29.05%, 20.43%, 15.29%, 14.67% and 10.50% of long jump performance. The stepwise multi-linear regression analysis proceeds to an equation: Long Jump Performance = 5.736 – 0.189 (Agility) + 0.031 (Muscular Strength). Agility, muscular strength, power, cardiovascular endurance, speed, muscular endurance and coordination are long jump performance's predictors, but agility and muscular strength are the 1st and 2nd best's; respectively.

P68. DO SYNCHRONIZED AUDITORY TONES FACILITATE VISUAL RHYTHM PERCEPTION?

Yao Li[1], Hui Li[2] & Yan Bao[1,2]

[1]Peking University, Beijing, China; [2]Ludwig-Maximilians-Universität, Munich, Germany

Rhythm perception is typically associated with auditory stimuli with regular temporal patterns, but it also exists in visual domain as demonstrated recently in a visual search study (Li et al., 2014). Using a dynamic search display with periodically moving objects, Li and colleagues have shown that searching for a target defined by a unique visual rhythm is not a "pop-out" process, but a serial one that demands considerable attention. The present study further asks whether synchronized auditory tones may facilitate visual rhythm search, thus leading to a more efficient search process. To address this question, we presented a series of tones with either regular or irregular temporal patterns during the presentation of a visual search display where a number of dots were bouncing periodically. Participants were asked to search for a target with a unique visual rhythm, i.e., a dot with either faster or slower tempo among all other same tempo distractors. The results showed that synchronized auditory tones can improve the search efficiency of vertically bouncing dots independent of target type (faster or slower rhythm targets). The present study demonstrated a cross-modal congruency effect in rhythm perception, possibly suggesting a common or shared mechanism between visual rhythm and auditory rhythm perception.

P69. PRE-STIMULUS ALPHA POWER AND PHASE COHERENCE IN THE VISUO-PARIETAL-FRONTAL NETWORK PREDICTED THE OUTCOME OF BISTABLE APPARENT MOTION

Lu Shen[1*]; Lihan Chen[4*]; Biao Han[5, 6]; Qi Chen[1,2,3]

[1]Center for Studies of Psychological Application and School of Psychology, South China Normal University, Guangzhou, 510631, China; [2]Guangdong Key Laboratory of Mental Health and Cognitive Science, South China Normal University, Guangzhou 510631, China; [3]Epilepsy Center, Guangdong 999 Brain Hospital, Guangzhou 510631, China; [4]Department of Psychology, Peking University, 100871, Beijing, China; [5]Centre National de la Recherche Scientifique, Unité Mixte de Recherche 5549, Faculté de Médecine de Purpan, 31052, Toulouse Cedex, France ; [6]Université de Toulouse, Centre de Recherche Cerveau et Cognition, Université Paul Sabatier, 31062, Toulouse, France

Upon viewing dynamic scenes, perceptual grouping needs to operate simultaneously in space and time. Ternus display, an apparent motion paradigm, which involves either dominant temporal grouping or dominant spatial grouping and accordingly results in either element motion (i.e. EM) or group motion (i.e. GM), is a useful tool for studying the neural mechanism underlying the perceptual grouping across spatial and time domain. By using functional magnetic resonance imaging (fMRI) and electroencephalogram (EEG) techniques, we asked participants to discriminate the type of apparent motion (GM vs. EM), and identified pre-stimulus and post-stimulus neural signals that were associated with specific perception. FMRI results showed that the perception of EM was associated with enhanced brain activity in the left parietal cortex and reduced activity in the default-mode-network, suggesting that the EM

perception involved more attention. EEG results further confirmed that reduced pre-stimulus occipital alpha power, a signature of attention, resulted in EM. Moreover, fMRI results showed that the perception of GM was modulated by increased connectivity between bilateral fusiform and both V5/MT and motor regions. EEG results further suggested that this enhanced connectivity might be correlated with more effective regional communication through phase coherence. Taken together, these findings suggest that the attentive states of the brain and the neural interaction between the ventral and dorsal stream may contribute to the specific spatio-temporal grouping, respectively.

P70. BAYESIAN PERCEPTUAL MODEL OF THE KAPPA EFFECT

Youguo Chen

Key Laboratory of Cognition and Personality (Ministry of Education), Center of Studies for Psychology and Social Development, Faculty of psychology, Southwest University, Chongqing, China;

In the Kappa effect, two visual stimuli are given, and their distance affects their perceived temporal interval. The classical model assumes a linear combination of actual time and an expected time, and it can be written as a Bayesian model with an appropriate assumption. Recent studies suggest that magnitude information is transformed into logarithmic space and combined with Bayes rule. Here we introduce a new experiment to distinguish between these hypotheses. When fit to the data, log-normal model makes better behavioral predictions than the linear model. Our findings suggest that the Kappa effect appears to occur in log-normal space.

P71. CROWDING SUPPRESSES THE GENERATION OF P300

Chunhua Peng

Laboratory of Cognition and Mental Health, Chongqing University of Arts and Sciences, Chongqing 402160, China

The term “crowding” refers to impaired peripheral object identification due to the presence of nearby objects. In this study, event-related potentials (ERPs) were used to investigate the relationship between crowding and the working memory processing by combining a crowding task with an oddball paradigm. Results showed that the P300 component, an index of working memory processing, was elicited by uncrowded words but rather than the crowded. These results suggest that crowding damages working memory processing of words.

P72. THE INFLUENCE OF VISUAL APPARENT MOTION ON AUDITORY TIME PERCEPTION

Jiashuang Wu, Han Yan, Zhenzhu Yue

Department of Psychology, Sun Yat-sen University

In the present study, we investigated whether auditory time perception was modulated by visual apparent motion. Moreover, the perceived speed of visual apparent motion was also manipulated. In each trial, five successive visual stimuli were shown on the computer monitor, while five auditory stimuli were presented via a headphone simultaneously. The 1-3, and 5th visual stimuli were two vertical bars separated by a distance, while the auditory stimuli were 500 ms pure tones. For the 4th stimuli, two visual bars were presented sequentially (i.e. visual apparent motion), and auditory stimuli lasted 380ms, 450 ms, 480 ms, 520 ms, 550 ms, or 620 ms in the apparent motion condition, while the visual and auditory stimuli did not change in the static condition. At the end of each trial,

participants estimated the length of the fourth auditory tone, and judged whether the duration of the auditory tone was longer or shorter than other durations. We found that the auditory time intervals were perceived as shorter in the static condition than in the apparent motion condition, i.e. the duration was perceived significantly longer in the slow apparent motion condition than in the static condition. This pattern suggests that the visual apparent motion alters the auditory time perception, which could be attributed to the distraction of visual attention from the auditory temporal processing.

P73. EXPECTANCY EFFECT ON AUDIOVISUAL BENEFIT OF MANDARIN LEXICAL TONES

Rui Wang[1], Xun He[1], Biao Zeng[1, 2]

[1] Psychology Department, Bournemouth University; [2] iTalkTone Lab

Speech processing benefits from watching articulating faces. Neurologically, this benefit results in audiovisual reduction effect (AV-V<A) that additional visual speech information reduces amplitudes and latencies of the activities in auditory cortex. van Wassenhove and colleagues (2005) found that reduction effect is independent of expectancy effect induced by blocked-design and randomised-design tasks. In blocked-design, auditory-only, visual-only and audiovisual modalities were presented in blocks, respectively. In randomised-design, modalities were presented randomly. Blocked-design brings about great expectancy compared to randomised-design. The stimuli used in their study were consonants which provide stronger visual cues, consequently the visual recognition could be easier compared to visualising Mandarin lexical tones which contain limited visual cues; hence audiovisual benefit of lexical tones in these tasks might yield different results. The present study compared audiovisual benefit effect of Mandarin lexical tones in auditory event-related potential (ERP) N1 with blocked-design and randomised-design tasks in same-different discrimination paradigm. The results revealed that amplitude-benefit was only found in randomised-design. In blocked-design, a long-lasting negative activity started before the onset of auditory information, leading to increasing N1 amplitude in audiovisual condition, while such a negative activity was not found in randomised-design, suggesting that expectancy effect might offset amplitude-benefit. Latency-benefit existed in both designs, and N1 peak was generally earlier across modalities in blocked-design than in randomised-design, which indicates that expectancy effect speeds up early auditory processing.

P74. COVERT ATTENTION IMPAIRS THE PERCEIVED CONTRAST AT HIGH-CONTRAST LEVELS

Liufang Zhou, Shena Lu, Yongchun Cai

Zhejiang University

Does attention alter the perceived contrast? Carrasco et al. (2004) firstly reported that covert attention boosts the apparent contrast. However, the conclusion has been questioned as a result from decision bias (Schneider & Komlos, 2008; Kerzel et al., 2010). Here we systematically studied the attentional effect over a wide range of contrast levels. Two different tasks were used: a comparative task (which stimulus looks higher/lower in contrast?) and a bias-resistant equality judgment task (whether the two stimuli look the same in contrast?). Attention was manipulated in a classical cueing paradigm. First, we found a strong response bias in comparative tasks: subjects tend to choose the cued stimulus, which makes the results less reliable. Second, the results from equality judgment task revealed that the cueing effect is dependent on the contrast level: a null effect was found at low-contrast levels (15% and 25%); surprisingly, a negative effect of cue emerged at high-contrast levels (40% and 60%). These suggest that sometimes attention does alter appearance, at least when the contrast is very high above threshold. The impairment seems counter-intuitive, yet may indicate an energy-saving coding strategy in our perceptual system.

P75. MULTISENSORY ENHANCEMENTS IN STROKE PATIENTS

Ayla Barutchu[1], Charles Spence[1], & Glyn W. Humphreys[1]

[1]Department of Experimental Psychology, University of Oxford, Oxford, OX1 3UD, UK

Multisensory integration has long been known to enhance information processing under a variety of conditions throughout the lifespan, however, it is not known to what extent stroke patients in general, with motor and cognitive impairments, can benefit from multisensory integration. We aimed to further investigate multisensory processing in 30 stroke patients with perceptual, cognitive and motor impairments, and 29 age matched controls using simple audiovisual detection and visual discrimination tasks. Participants responded to auditory, visual and spatially congruent and incongruent audiovisual presentations of squares and pure tones (200 ms duration). Multisensory stimuli were always temporally coincident, however, in the visual discrimination task audiovisual signals were spatially incongruent at times. Healthy control participants responded to all signals with very high accuracy (M accuracy > 95% for all stimuli). Multisensory gains were also observed for both spatially congruent and incongruent presentations of multisensory stimuli. Participants with stroke also showed large multisensory gains in both accuracy and reaction times. Some participants with perceptual impairments even showed enhanced multisensory gains. The data show that perceptual and motor processes can be enhanced in patients with stroke using temporally coincident signals. Multisensory integration may serve as an important vehicle for new rehabilitation strategies aiming to improve perceptual, cognitive and motor impairments.

P76. AUDITORY-VISUAL INTEGRATION AND MODALITY SWITCH IN HUMAN AND MONKEY

Cécile Juan, Céline Cappe, Baptiste Alric, Benoit Roby, Pascal Barone and Pascal Girard

Centre de recherche Cerveau et Cognition, Centre National de la Recherche Scientifique, UMR 5549, Toulouse, France

There is a large body of studies showing in both human and animal models that multisensory interaction (MSI) leads to an enhancement of perceptive and behavioral performances. In simple detection tasks MSI is expressed as a decrease in reaction times (RTs) with a gain that is specifically important when approaching to the perceptive threshold. While this phenomenon is commonly accepted based on global analysis of performances, some limitations of these multisensory rules have been proposed based on the analysis of source of variability (Otto & Mamassian 2012). Amongst the origins of variability is the effect of task switching (Mounsell 2003) that could be present during successive presentation of different modalities. In the present study, we sought to determine whether modality switching can be generalized to human and non-human primates (NHP) performances of MSI and how the intrinsic properties of the stimuli participate to the individual variability. First we have trained 2 macaque monkeys to perform a simple reaction time task to a large set of 304 natural visual (V) and 304 auditory (A) stimuli and their visuo-auditory (AV) combination. This includes different categories: humans, monkeys, animals and inanimate, each presented in strong or weak salience. Second 9 human subjects performed a similar detection task using a different sample of 144 auditory and visual natural stimuli and their bimodal association. In both monkeys and humans, the presentation of stimuli (category, modality and salience) was randomized.
The overall AV RTs analysis replicates the large literature on multisensory integration with AV RTs being shorter than the RTs to V and A stimuli. First, our results did not obey the expected inverse effectiveness rule as the multisensory gains tended to be higher for salient stimuli than to less salient ones. In addition, there was no effect of the semantic congruence between A and V stimuli. Lastly, a close inspection of individual trials revealed a large variability in the individual MS gains to the different stimuli conditions with a large number of the gains being negative. A significant violation of the race model was observed only for the most positive gains. We observed that a major contribution to the variations of the MS gains was the sequential order of the modalities in the RT task. In general, but depending on subjects, a visual RT trial speeded up the RT to the next V or AV trial while an auditory trial slowed down the next response to a V or AV presentation. In conclusion, our results present evidence that in both human and NHP the switch in sensory modalities strongly modulates MSI benefits.

P77. MOVEMENTS OF AVATAR IN VIRTUAL REALITY CAN ELICIT SENSE OF AGENCY

Gaiqing Kong, Kang He, Kunlin Wei*

Department of Psychology, Peking University

As an important component of self-awareness, sense of agency (SOA) refers to experiencing oneself as the author of one's action. Studies on rubber hand illusion and its virtual-reality (VR) variants demonstrate that body ownership, another part of self-awareness, can be transferred to external objects or virtual effectors (Matthew Botvinick & Jonathan Cohen, 1998; Ehrsson, 2004; Olaf Blanke et al., 2007). However, whether sense of agency can be similarly attributed to avatar in VR has never been rigorously examined (Ke Ma et al., 2015). Here we use intentional binding, a well-established implicit measure of SOA, to study whether movements of an avatar can trigger SOA after sensorimotor experience in VR. Participants wore a head-mounted display (HMD, Rift DK2, Oculus) and a data glove (Perception Neuron, Noitom), which measured their upper arm movements. They were immersed in a virtual environment with a first-person perspective and a gender-matched virtual body. The experiment consisted of a pretest, an exposure phase and a posttest. In the pretest and posttest, we measured intentional binding with a Libet's clock (Haggard, 2002). When a voluntary action is followed by a delayed action outcome, people's estimate of the outcome timing is biased towards the action. In our experiment, participants observed their avatar's right hand press a lever and received a vibrotactile stimulus delivered to their own left hand 250ms later. They were asked to report the time of the stimulus. The bias was computed by comparing this estimate to the estimate from a baseline condition without the avatar's action. During the 25-min exposure phase, participants (n=18; Test group) perform two aiming tasks by moving their upper limb while the avatar arm matched the real arm continuously and simultaneously. Another participant group (n=18; VR-Control group) went through the same procedures except that the avatar was not shown during exposure. We recruited a third group (n=18; Reality-Control group) performed the intentional binding task with their real hand and without HMD. We found that intentional binding was stronger after exposure in Test group. This exposure effect was absent in VR-Control group as no significant difference was detected before and after exposure. Interestingly, the size of the intentional binding in Test group was comparable to that of Reality-Control group. Hence, similar to bodily ownership, SOA can also be attributed to virtual identities after a short period of immersive VR experience. Our novel behavioral paradigm offers an opportunity to further elucidate the cognitive and neural mechanisms of self-consciousness. As VR is extensively used in motor control studies as a surrogate of real environment, our findings intriguingly suggest that virtual body or virtual representation of the body might dynamically affect SOA and its related sensorimotor control processes.

P78. DEACTIVATION OF ASSOCIATION CORTICES DISRUPTED THE CONGRUENCE OF VISUAL AND AUDITORY RECEPTIVE FIELDS IN SUPERIOR COLLICULUS NEURONS

Liping Yu, Jihong Xu

Key Laboratory of Brain Functional Genomics of Chinese Ministry of Education, School of Life Science, East China Normal University, Shanghai 200062, China

Physiological and behavioral studies in cats show that corticotectal inputs plays a critical role in the information-processing capabilities of neurons in the deeper layers of the superior colliculus (SC). Among them, the sensory inputs from functionally related associational cortices are especially critical for SC multisensory integration. However, the underlying mechanism supporting this influence is still unclear. Here, results demonstrate that deactivation of relevant cortices can both dislocate SC visual and auditory spatial receptive fields (RFs) and decrease their overall size, resulting in reduced alignment. Further analysis demonstrated that this RF separation is

both significantly correlated with the decrement of neurons' multisensory enhancement (ME) and is most pronounced in low stimulus intensity conditions. In addition, cortical deactivation could influence the degree of stimulus effectiveness, thereby illustrating the means by which higher-order cortices may modify the multisensory activity of SC.

P79. REWARD EXPECTATION REGULATES BRAIN RESPONSES TO EMOTIONAL FACES IN GENDER DISCRIMINATION TASK: ERP EVIDENCE

Lulu Wu, Ping Wei

Beijing Key Laboratory of Learning and Cognition and Department of Psychology, Capital Normal University, Beijing 100048, China

The effect of reward expectation on emotional facial expressions was investigated in a gender discrimination task using event-related potentials (ERPs). A cue indicating the reward condition of each trial (incentive vs non-incentive) was followed by the presentation of an emotional face target (positive, neutral, negative). Participants were asked to discriminate the gender of the target face. The reaction times were shorter for the incentive trials than for the non-incentive trials, and were shorter for positive targets than for neutral and negative targets, demonstrating the effect of reward to facilitate task performance and the advantage of positive faces in gender categorization. Although there was no interaction between reward expectation and emotional expression in behavioral results, such an interaction was evident in ERP results. Both anterior N2 and early posterior negativity revealed larger reward effects (i.e., brain responses to the non-incentive condition vs. the incentive condition) for the positive targets than for the neutral targets. Moreover, N2 also revealed a diminished negative bias effects in the incentive condition than in the non-incentive condition. These results suggest that top-down incentive motivation flexibly biased attentional processing toward target emotion to better facilitate task performance, with increased sensitivity to positive facial expressions but reduced response to negative emotion.

P80. USING MACHINE LEARNING AS A TOOL FOR CLASSIFICATION OF AUTISM SPECTRUM DISORDER

Qiao He, Li Yi and Kunlin Wei

Department of Psychology, Peking University

Autism Spectrum Disorder (ASD) is a broad and pervasive neurodevelopmental disorder, characterized by repetitive movements and impairments in social communication and cognitive abilities. The early diagnosis of ASD has always been a challenge for both scientists and clinicians. Since infants later diagnosed as ASD display specific eye movement patterns, we hypothesize that eye movement data might serve as features for automatic classification of ASD. Using common machine learning classifiers and eye movement data from a facial recognition task, we demonstrated that adults with ASD, adults with comparable IQ (intellectually disabled, ID group) and typical developed adults (TD group) could be distinguished with decent accuracy. We were able to reach a maximum classification accuracy of 72% for classifying three groups with seven features and a naïve Bayes classifier. The selected features also demonstrated specific saccade and fixation patterns that are not recognized in previous studies. Our findings indicate that eye movements during face processing tasks might assist early screening or diagnosis of infantile ASD.